OFFICE OF THE MAYOR

CITY OF CHICAGO

HAROLD WASHINGTON
MAYOR

MEDICAL ASPECTS OF PROPOSAL TO BAN THE SALE OF LEADED GASOLINE

FACT SHEET

1. Lead is neither a normal nor necessary constituent of the human body. In fact, lead is harmful to humans when absorbed into the body, and there exists a continuum of harmful effects ranging to severe life threatening conditions at high lead levels in the body to subclinical manifestations at lower levels that may nonetheless have serious and longlasting squelae. These examples would include the following:

   - Death due to lead encephalopathy and renal dysfunction at blood lead levels of 80 and above.

   - Anemia, anorexia, abdominal pain, and vomiting at levels of 70 and above.

   - Reduced hemoglobin production with cognitive and central nervous system deficits and slowed nerve conduction velocity at levels of 40 and above.

   - Interference with Vitamin D metabolism at levels of 30 and above.

2. While there is much debate about neurological effects in children at low blood levels (that is those levels below 30) there is better evidence of such effects at elevated levels. Nevertheless, the effects from low levels of lead exposure on biochemical, hematological, neurological, and other systems are known to exist. These include the following:

- Inhibition of various cellular enzymes at levels beginning at 10 micrograms per deciliter.

- Elevated levels of zinc protoporphyrin beginning at levels of about 15 micrograms per deciliter.

- Changes in electrophysiological responses (such as altered slow wave brain patterns) beginning at levels of about 15 micrograms per deciliter.

- Increased levels of certain metabolic acids at levels of about 10.

- Inhibition of Vitamin D pathways at levels as low as 10.

- Inhibition of globin synthesis at levels of about 20.

The medical significance of these pathophysiological effects of low blood lead levels is not fully understood. However, they pose areas of significant and potential concern including their eventual effects on the hematologic system, on the development of the fetus, and on subtle neurologic effects such as small effects on I.Q. and other behavioral dysfunctions such as learning disabilities, behavioral disorders, and developmental delays.

3. Lead can be absorbed into the body as a result of a variety of environmental exposures including the ingestion of paint chips and inhalation or ingestion of dust or soil contaminated with lead.

   - While lead paint chips remain a source of potential acute and severe problems, more than half of all Chicago children found to have lead levels above 30 had no identifiable source of exposure to lead paint chips.

- Studies across the country document that there is a direct relationship between lead levels in the air and lead levels in the body, even after exposure to lead paint chips or other acute sources of ingestion are considered.

- Data demonstrates that the vast majority of lead present in the air comes from tailpipe emissions from internal combustion engines burning leaded gasoline.

- Numerous studies showed that lead deposited in the soil and dust from the air accumulates there and that urban and high trafficked areas show higher levels in the soil and dust than rural areas.

- Lead levels in Chicago playgrounds, parks, and schoolyards consistently demonstrated levels 4-20 times higher than the so-called normal levels. Ingestion of as little as one teaspoon of soil from these playgrounds would contribute more than 30 times the recommended maximum intake of lead into the bodies of our young children.

4. Bans on the sale of lead based paint and some lead screening programs (even in concert with inspection and correction of lead hazards in older housing units) are simply not enough to protect our children.

5. To reduce exposure among all children, even those not at risk of ingesting lead paint chips, we must remove the source of contamination of our air, soil, and dust. This is possible to a great extent through a ban on the sale of leaded gasoline as enacted in the City of Chicago and Cook County, Illinois.

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TESTIMONY ON BAN OF LEADED GASOLINE SALES

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THE CHICAGO DEPARTMENT OF HEALTH URGES THE COOK COUNTY BOARD TO VIGOROUSLY PURSUE BANS ON THE SALE OF LEADED GASOLINE TO PROTECT THE HEALTH OF OUR CHILDREN, PREGNANT WOMEN, AND THE UNBORN.

WHILE HEALTH OFFICIALS HAVE BEEN AWARE OF THE ACUTE TOXIC EFFECTS OF LEAD ABSORBED INTO HUMAN BODIES FOR SOME TIME, WE HAVE NOT UNTIL RECENTLY BECOME AWARE OF THE SERIOUS PROBLEMS CAUSED BY BODY LEAD LEVELS PREVIOUSLY BELIEVED TO BE SAFE. TOO OFTEN IN THE PAST, WE HAVE EQUATED LEAD EFFECTS WITH THE SEVERLY CONVULSING TODDLER WHO IS OFTEN DISCOVERED ONLY WHEN HE IS NEAR DEATH. NOW WE KNOW THAT MUCH LOWER LEVELS OF LEAD IN THE BODY CONTRIBUTED TO LEARNING DISABILITIES, DEVELOPMENTAL DELAYS, BEHAVIORAL PROBLEMS, REPRODUCTIVE LOSS, AND OTHER SERIOUS HEALTH PROBLEMS.

AT THIS POINT, I WOULD LIKE TO SUMMARIZE SOME OF THE IMPORTANT INFORMATION ON THE HEALTH EFFECTS OF LEADED GASOLINE. VIRTUALLY ALL HEALTH AND ENVIRONMENTAL ADVOCATES AGREE THAT EXPOSURE TO ENVIRONMENTAL LEAD IS TRULY A NATIONAL HEALTH PROBLEM. UNFORTUNATELY, THAT NATIONAL HEALTH PROBLEM MANIFESTS ITSELF

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BY AFFECTING INDIVIDUALS AT A LOCAL LEVEL. WHILE EXPOSURE TO ENVIRONMENTAL LEAD IS A NATIONAL HEALTH PROBLEM, THE RESULTS OF THOSE EXPOSURES ARE MOST APPARENT AT THE LOCAL, INDIVIDUAL LEVEL. OVER THE PAST TWO DECADES, NUMEROUS STUDIES HAVE BEEN PERFORMED TO ASSESS THE IMPACT OF LEAD ABSORBED INTO THE BODY. OVER THE COURSE OF THOSE TWO DECADES, THE ACCEPTABLE LIMITS OF BLOOD LEAD WITHIN THE BODY HAS BEEN REDUCED TIME AND TIME AGAIN. A RECOMMENDATION OF THE CENTERS FOR DISEASE CONTROL'S CHILDHOOD LEAD POISONING PREVENTION ADVISORY COMMITTEE IN MAY OF 1984, WAS TO LOWER THE DEFINITION OF ELEVATED BLOOD LEAD FROM THE CURRENT 30 MICROGRAMS PER DECILITER TO 25 MICROGRAMS PER DECILITER. THIS REPRESENTED THE HEIGHTENED CONCERN OF FEDERAL HEALTH AND ENVIRONMENTAL AUTHORITIES ABOUT HEALTH EFFECTS NEWLY REPORTED TO BE ASSOCIATED WITH LOWER LEVEL LEAD EXPOSURE. THOSE CONCERNS UNDERSCORE THE NEED TO NOT ONLY REDUCE ENVIRONMENTAL EXPOSURES TO LEAD, BUT TO ELIMINATE THEM ENTIRELY WHEREVER POSSIBLE.

THE RELATIONSHIP BETWEEN GASOLINE AND BLOOD LEAD LEVELS HAS BEEN STUDIED ACROSS THE COUNTRY. THESE STUDIES CONSISTED OF VARIOUS STATISTICAL ANALYSES OF POPULATIONS' BLOOD LEAD DATA AND VARIOUS INDICATORS

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OF GASOLINE LEAD CONSUMPTION. THESE INCLUDE A REVIEW OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS BY THE ENVIRONMENTAL PROTECTION AGENCY, THE SECOND NATIONAL HEALTH AND NUTRITION EXAMINTATION SURVEY PERFORMED BY THE NATIONAL CENTER FOR HEALTH STATISTICS, ADDITIONAL STUDIES PERFORMED BY THE CENTERS FOR DISEASE CONTROL IN CONJUNCTION WITH THE NATIONAL CENTER FOR HEALTH STATISTICS, AND VARIOUS SPECIALIZED STUDIES. ONE OF THOSE STUDIES EXAMINED THE BLOOD LEAD/GASOLINE LEAD RELATIONSHIP USING THREE DIFFERENT BLOOD LEAD DATA-BASES FOR CHICAGO. THIS STUDY WAS PERFORMED IN 1983, AND FOUND A STRONG RELATIONSHIP BETWEEN BLOOD LEAD AND GASOLINE LEAD FOR EACH BLOOD LEAD DATABASE. IN ANALYZING THE CHICAGO BLOOD LEAD DATA, THE STUDY ALSO FOUND THAT REDUCED PAINT LEAD EXPOSURE DID NOT COMPOUND THE RELATIONSHIP BETWEEN BLOOD LEAD AND GASOLINE LEAD BECAUSE THE RELATIONSHIP WAS SIGNIFI-CANT EVEN FOR CHILDREN WHO LIVED IN HOUSES WITH NO LEAD PAINT. THAT SAME STUDY ALSO ANALYZED ADULTS SEPARATELY AND FOUND THE SAME EFFECT, WHICH AGAIN INDICATES THAT PAINT LEAD IS NOT A COMPOUNDING FACTOR SINCE ADULTS DO NOT EAT PAINT CHIPS.

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AMONG OTHER IMPORTANT SPECIALIZED STUDIES, ONE 1983 STUDY ON UMBILICAL CORD LEAD LEVELS SHOWED A STRONG RELATIONSHIP BETWEEN GASOLINE LEAD AND UMBILICAL CORD LEAD LEVELS IN THE BOSTON AREA.

BASED UPON ALL OF THESE STUDIES, THE FEDERAL EPA HAS CONCURRED WITH ITS PREVIOUS FINDINGS THAT THERE IS A STRONG RELATIONSHIP BETWEEN GASOLINE LEAD USAGE AND BLOOD LEAD LEVELS. THE EPA FOUND THAT THE EXISTING STUDIES PROVIDE STRONG EVIDENCE DEMONSTRATING THE EXISTENCE OF A DIRECT RELATIONSHIP BETWEEN GASOLINE LEAD AND BLOOD LEAD LEVELS.

THIS IS CRITICALLY IMPORTANT IN VIEW OF THE WELL DOCUMENTED EFFECTS OF ELEVATED BLOOD LEAD LEVELS ON HUMAN BEINGS. THIS LIST OF DEMONSTRATED HEALTH EFFECTS OF BLOOD LEAD LEVELS EXCEEDING 30 MICROGRAMS PER DECILITER IS WELL ESTABLISHED. THESE EFFECTS INCLUDE THE FOLLOWING:

- DEATH DUE TO LEAD ENCEPHALOPATHY AND RENAL DYSFUNCTION AT BLOOD LEVELS OF 80 AND ABOVE.

- ANEMIA, ANOREXIA, ABDOMINAL PAIN, AND VOMITING AT LEVELS OF 70.

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- REDUCED HEMOGLOBIN, COGNITIVE AND CENTRAL NERVOUS SYSTEM DEFICITS AND SLOWED NERVE CONDUCTION VELOCITIES AT LEVELS OF 40 AND ABOVE.

- VITAMIN D METABOLISM INTERFERENCE AT LEVELS OF 30 AND ABOVE.

WHILE THERE IS MUCH DEBATE ABOUT NEUROLOGICAL EFFECTS IN CHILDREN AT LOW BLOOD LEVELS (THAT IS THOSE BELOW 30) THERE IS BETTER EVIDENCE OF SUCH EFFECTS AT ELEVATED LEVELS.

THE EFFECTS FROM LOW LEVELS OF LEAD EXPOSURE ON BIOCHEMICAL, HEMATOLOGICAL, NEUROLOGICAL, AND OTHER SYSTEMS ARE KNOWN TO EXIST. MANY STUDIES, INCLUDING A NUMBER OF THOSE PERFORMED BY EPA, FOUND THAT THERE IS A CONTINUUM OF EFFECTS FROM LOW LEVEL EXPOSURES RELATED TO BIOCHEMICAL CHANGES TO DEATH AT HIGH EXPOSURES. BASED UPON SEVERAL SUMMARIES AND SCIENTIFIC AND MEDICAL LITERATURE, IT IS REASONABLE TO CONCLUDE THAT THERE EXISTS AN APPARENT CONTINUUM OF PATHOPHYSIOLOGICAL EFFECTS ASSOCIATED WITH LOW LEVEL LEAD EXPOSURE. THIS CONTINUUM IS ILLUSTRATED BY THE FOLLOWING EFFECTS:

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- INIHIBITION OF VARIOUS ENZYMES AT LEVELS BEGINNING AT 10 MICROGRAMS PER DECILITER.
- ELEVATED LEVELS OF ZINC PROTOPORPHYRIN BEGINNING AT LEVELS OF ABOUT 15 MICROGRAMS PER DECILITER.
- CHANGES IN ELECTRO-PHYSIOLOGICAL RESPONSES SUCH AS ALTERED SLOW WAVE BRAIN PATTERNS BEGINNING AT LEVELS OF ABOUT 15 MICROGRAMS PER DECILITER.
- INCREASED LEVELS OF CERTAIN ACIDS AT LEVELS OF ABOUT 10.
- INHIBITION OF VITAMIN D PATHWAYS AT LEVELS AS LOW AS 10.
- INHIBITION OF GLOBIN SYNTHESIS AT LEVELS OF ABOUT 20.

THE MEDICAL SIGNIFICANCE OF THESE PATHOPHYSIOLOGIC EFFECTS OF LOW BLOOD LEAD LEVELS IS NOT YET FULLY UNDERSTOOD. HOWEVER, THEY POSE AREAS OF SIGNIFICANT AND POTENTIAL CONCERN INCLUDING THEIR EVENTUAL EFFECTS ON THE HEMATOLOGIC SYSTEM, ON THE DEVELOPMENT OF THE FETUS, AND ON SUBTLE NEUROLOGIC EFFECTS SUCH AS A SMALL EFFECT ON I.Q. AND OTHER BEHAVIORAL DYSFUNCTIONS SUCH AS LEARNING DISABILITIES, BE-

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HAVIORAL DISORDERS, AND DEVELOPMENTAL DELAYS. A NUMBER OF RECENT STUDIES HAVE DEMONSTRATED CLEAR ASSOCIATIONS BETWEEN AUCH SUBTLE HEALTH PROBLEMS AND LEAD LEVELS PREVIOUSLY BELIEVED TO BE SAFE AND NORMAL. WE NOW KNOW THAT SUCH LEVELS ARE NOT SAFE, AND CERTAINLY, THEY ARE ANYTHING BUT NORMAL. BASED UPON ALL OF THIS EVIDENCE, IT IS REASONABLE TO CONCLUDE THAT SOME TYPES OF NEUROPSYCHOLOGICAL EFFECTS ARE THE RESULT OF LOW LEVEL LEAD EXPOSURE AMONG CHILDREN. IT IS APPARENT THAT THERE IS NO HEALTH BASED REASON TO CONTINUE THE USE OF LEAD IN GASOLINE, AS THIS IS THE MOST READILY CONTROLLED AND MOST UBIQUITOUS SOURCE OF LEAD EMISSION INTO THE ENVIRONMENT.

IN AN EFFORT TO RID THE ENVIRONMENT OF UNNECESSARY AND HARMFUL LEAD, WE MUST NOT BE CONTENT WITH BANS IMPOSED UPON THE SALE OF LEADED PAINTS OR LEAD SCREENING PROGRAMS FOR OUR SMALL CHILDREN. WE MUST WORK TO RID OUR ENVIRONMENT OF LEAD FROM ALL SOURCES.

TAILPIPE EMISSIONS CLEARLY CONTAMINATE OUR AIR, OUR DUST, AND OUR SOIL. THE CHICAGO DEPARTMENT OF HEALTH, IN COOPERATION WITH THE COALITION TO BAN LEADED GASOLINE, HAS TESTED SOIL SAMPLES FROM CHICAGO PLAYGROUNDS, PARKS, AND GARDENS AND FOUND UNACCEPTAB-

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LY HIGH LEVELS. THOSE LEVELS AVERAGE TWO TO SIX TIMES HIGHER THAN LEVELS ADVOCATED BY THE EPA TO BE SAFE. THESE FINDINGS CONFIRM OUR FEARS THAT OUR CHILDREN ARE AT RISK OF INGESTING OR INHALING LEAD THAT OFTEN TIMES LEADS TO BOTH SUBTLE OR ACUTE HEALTH PROBLEMS. (ATTACHED IS A REPORT OF OUR SOIL TESTING RESULTS.)

OUR EARLY FINDINGS DEMONSTRATE THAT LEAD IS BEING DEPOSITED IN THE SOIL OF OUR SCHOOLYARDS AND PLAYGROUNDS IN VIRTUALLY ALL AREAS OF THE CITY. WHILE SOME COMMUNITIES MAY PERCEIVE NO HEALTH RISK BECAUSE OF THE ABSENCE OF LEAD FROM PAINT CHIPS, NONE OF OUR COMMUNITIES AND NEIGHBORHOODS ARE FREE FROM LEAD IN THE AIR, DUST AND SOIL.

SINCE LEAD IS AN AVOIDABLE AND PREVENTABLE HEALTH HAZARD THAT CAN BE REDUCED THROUGH ADMINISTRATIVE, REGULATORY, OR LEGISLATIVE ACTIONS AVAILABLE TO US, I URGE THE COOK COUNTY BOARD AS WELL AS OUR ELECTED OFFICIALS IN SPRINGFIELD AND WASHINGTON TO FOLLOW THE LEAD OF CONCERNED CITIZENS HERE IN CHICAGO AND BAN LEADED GASOLINE SALES AS RAPIDLY AS POSSIBLE.

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 80

[AMS-FRL 2620-4]

Regulation of Fuels and Fuel Additives; Lead Phase Down

AGENCY: Environmental Protection Agency (EPA).

ACTION: Proposed rule.

SUMMARY: EPA is proposing a lead content standard of 0.10 gram of lead per gallon of leaded gasoline (gplg), effective January 1, 1986. This standard would replace the current standard of 1.10 gplg.

There are two reasons for EPA's proposal to reduce lead in gasoline. The misuse of leaded gasoline in vehicles designed for unleaded gasoline ("misfueling" or "fuel switching") is widespread and persistent. Misfueling poisons catalytic converters, resulting in a very high increase in emissions of several pollutants that adversely affect the public health and welfare (hydrocarbons, carbon monoxide, and nitrogen oxides). It has also resulted in higher lead usage than predicted by the Agency. The Agency is also increasingly concerned about the adverse health effects of lead in gasoline since its previous rulemaking on this subject in 1982, newly published studies and reanalyses of previously available information have heightened the Agency's concern about such effects.

The Agency is proposing a 1986 standard of 0.10 gplg instead of an immediate ban to effect EPA's objective because a large number of older vehicles (as well as other types of equipment) require a valve lubricant and it appears that no environmentally acceptable alternative to lead as such a lubricant is currently available. The Agency believes that the proposed standard of 0.10 gplg would provide an adequate amount of lead for this purpose. In order to assure that these vehicles receive an adequate amount of lead, EPA is also proposing elimination of the provisions in the regulations that allow the averaging of lead usage by refineries. The effective date of January 1, 1986, for the standard has been selected in order to allow the refining industry sufficient time to take actions needed to produce adequate amounts of unleaded and very low-lead gasoline, which the Agency believes is generally possible through the use of existing refinery equipment. In case comments lead EPA to believer that 1986 is not a feasible date, EPA is also considering alternative compliance schedules for a phased-in approach, such as 0.50 gplg on July 1, 1985, 0.30 gplg on January 1, 1986, 0.20 gplg on January 1, 1987, and 0.10 gplg on January 1, 1988.

The Agency is proposing two approaches relating to long term lead usage. The first would ban lead in gasoline by about 1995 by regulation. The second would impose no additional regulatory action beyond the 0.10 gplg standard on the premise that the reduction in total lead usage caused by vehicle and engine turnover would eliminate the need for lead and therefore its use.

EPA expects that its proposed 0.10 gplg standard would reduce lead usage in gasoline by at least 91 percent starting in 1986. The amount of fuel switching, and hydrocarbon/carbon monoxide/nitrogen oxide emission increases that are caused by this practice, should also be reduced significantly. The benefits from such reductions include reduced blood lead levels and related medical costs, benefits from reductions in tailpipe emissions of other pollutants, and savings in vehicle maintenance costs. A total ban on lead usage would have been greater health and other benefits.

DATES: A public hearing will be held on August 30 and 31, 1984, from 9:00 a.m. to 4:30 p.m. at the location listed below, in order to provide an opportunity for oral presentations of data, views, or arguments concerning the regulations proposed in this notice. Persons who wish to testify at this hearing should notify Richard Kozlowski at the address listed below prior to August 17, 1984.

Written comments must be submitted to the location listed below by October 1, 1984.

ADDRESSES: The public hearing will be held at the Hyatt Arlington (at Key Bridge), 1325 Wilson Blvd., Arlington, Virginia.

Written comments should be sent to Docket No. EN-84-05, Central Docket Section (LE-131), Environmental Protection Agency, 401 M Street, SW., Washington, D.C. 20460. The docket is located in the West Tower Lobby of EPA, 401 M Street, SW., Washington, D.C., and may be inspected between 8:00 a.m. and 4:00 p.m. on weekdays. As provided in 40 CFR Part 2, a reasonable fee may be charged for photocopying. To expedite review, it is also requested that a duplicate copy of written comments be sent to Richard Kozlowski at the address listed below.

FOR FURTHER INFORMATION CONTACT: Richard G. Kozlowski, Director, Field Operations and Support Division (EN-397F), EPA, 401 M Street, SW., Washington, D.C. 20460. Telephone (202) 382-2633.

SUPPLEMENTARY INFORMATION:

I. Background

A. February 22, 1982, Notice of Proposed Rulemaking

On February 22, 1982, EPA announced that it would consider whether conditions justified rescission or modification of its regulations (promulgated in 1973) requiring refiners to meet a 0.5 gram of lead per gallon of total (leaded and unleaded) gasoline (gptg) standard for the average lead content of gasoline. 47 FR 4812. This standard was then in effect for all refineries except those then classified as small refineries. Small refineries would have been subject to this standard beginning on October 1, 1982, absent any change in the regulations. EPA's decision to reconsider these regulations was based on the question or whether the standard was still necessary due to the ever-increasing use of unleaded gasoline in this country, as all new cars now require the use of unleaded fuel to protect their emission control systems. EPA's notice listed alternative actions ranging from retention of the 0.5 gptg standard to rescission of the regulations, and requested comments on the various alternatives. On the same date, EPA proposed to suspend indefinitely the October 1, 1982, compliance data for small refineries to comply with the 0.5 gptg standard, pending completion of the review of the regulation. 47 FR 4814.

B. August 27, 1982, Rulemaking Notices

Based on a review of voluminous comments and testimony on the February 22 NPRM, as well as on information developed by the Agency, EPA issued three rulemaking notices on August 27, 1982.

In the first notice, EPA announced that it would not relax or rescind the overall standard of 0.5 gptg and therefore was withdrawing that portion of the February 22 proposal. 47 FR 38070. The Agency noted that the lead phasedown program had been based on the premise that gasoline lead emissions should be controlled to the extent possible. 47 FR 38072. EPA determined that rescinding or relaxing the lead standard would result in an increase in lead emissions to the atmosphere, that environmental lead exposure continued to be a national health concern, and that there was no new information that would lead EPA to determine that continuing control of lead in gasoline is not appropriate.

In a second notice, EPA proposed regulations to replace the standard of 0.5 gplg (based on the average lead content of all gasoline produced by a refinery) with a two-tiered standard regulating the lead content of leaded gasoline only. 47 FR 38078. Under the proposal, larger refineries would have been subject to a standard of 1.10 gplg while small refineries would have been subject to a 2.50 gplg standard. This notice also proposed to amend the definition of a small refinery in a manner that would have reduced the number of facilities eligible for the less stringent 2.50 gplg standard. Another major element of the proposed regulations was a requirement that the average lead content of imported leaded gasoline sold or offered for sale not exceed 1.10 gplg. The final major element of the proposed regulations was a provisons that would have permitted two or more refineries, whether owned by the same refiner or not, and importers to average their lead usage over a calendar quarter.

In the third notice of rulemaking, EPA suspended the compliance date of the 0.5 gplg standard for small refineries from October 1, 1982, to October 31, 1982. 47 FR 38090.

C. October 29, 1982, Notice of Final Rulemaking

On October 29, 1982, EPA promulgated revised regulations governing the allowable lead content of leaded gasoline. 47 FR 49322. Effective November 1, 1982, large refineries and importers were made subject to a lead content standard of 1.10 gplg, as proposed. Small refineries were made subject to the 1.10 gplg standard starting on July 1, 1983, with an interim standard of 1.90 gplg for the November 1, 1982, to June 30, 1983, period. The eight-month interim period was designed to compensate for the period of uncertainty caused by the Agency's consideration of revisions to the lead content regulations. The small refinery definition was also significantly revised, resulting in a substantial decrease in the number of qualifying facilities. Finally, the regulations were revised to permit all refineries and importers to average their lead usage with each other.

In this notice, the Agency indicated its intention to take whatever action is necessary to assure that lead usage in gasoline continues to be reduced, should leaded gasoline consumption not decrease substantially in the future. 47 FR 49[illegible]

D. Actions by the U.S. Court of Appeals for the District of Columbia Circuit and EPA Responses

Petitions to review the regulations were filed by the Small Refiner Lead Phase-Down Task Force (SRTF), Plateau Incorporated, and Simmons Oil Company. These petitioners challenged various portions of the promulgated regulations, including the interim and permanent small refinery standards and the small refinery definition.

On January 26, 1983, the U.S. Court of Appeals for the District of Columbia Circuit issued an order in response to the challenges brought by SRTF and Plateau Inc. With one exception, the Court upheld the regulations. The exception was that the Court found the interim 1.90 gplg standard for small refineries to be defective because EPA did not give adequate notice that it might immediately require these facilities to reduce lead use significantly. As a result, the Court vacated that part of 40 CFR 80.20(b)(1)(i) that required small refineries to limit immediately the lead content of leaded gasoline to 1.90 gplg for gasoline production not exceeding the refinery's historic production level.

The Court delayed issuing its mandate in order to give EPA an opportunity to promulgate an emergency lead content regulation for the interim period. On February 1, 1983, the Agency issued an emergency rule, generally reinstituting until July 1, 1983, the lead content standards applicable to the affected small refineries prior to November 1, 1982 (2.15 and 2.65 gplg). See 48 FR 5724 (Feb. 8, 1983.).[1] Starting on July 1, 1983, the distinction in these regulations between large and small refineries was no longer applicable, as all refineries became subject to a 1.10 gplg standard on that date.[2]

On February 9, 1983, the Court issued an order in response to Simmons Oil's petition, which challenged the portion of the small refinery definition that precluded a facility from qualifying as a small refinery if, "during any period of ownership or control since July 1, 1981, it was owned or controlled by a refiner with total gasoline production greater than 70,000 barrels per day." 40 CFR 80.2(p)(3). The Court found that the addition of a past ownership requirement was procedurally flawed due to a lack of notice, and vacated this criterion in § 80.2(p)(3). The Court left in force the current ownership criterion in the provision.

On April 22, 1983, the Court issued an opinion explaining more fully the underlying reasoning for its February 9 order concerning the Simmons petition as well as for its January 26 order dealing with the other petitions. *Small Refiner Lead Phase-Down Task Force ("SRTF") v. E.P.A.*, 705 F.2d 506 (D.C. Cir. 1983). On issues related to the health effects of gasoline lead, the Court concluded:

> In summary, the demonstrated connection between gasoline lead and blood lead, the demonstrated health effects from blood lead levels of 30 ug/dl or above, and the significant risk of adverse health effects from blood lead levels as low as 10–15 ug/dl, would justify EPA in banning lead from gasoline entirely.

705 F.2d at 531.

On November 1, 1983, EPA took final action to revise § 80.2(p)(3) so as to be consistent with the Court's order concerning the Simmons petition. 48 FR 50482.

II. Statutory Authority

Section 211(c)(1) of the Clean Air Act, 42 U.S.C. 7545(c)(1), confers broad authority on the Administrator to "control or prohibit the manufacture . . . or sale" of any fuel or fuel additive whose emission products cause, or contribute to, "air pollution which may be reasonably anticipated to endanger the public health or welfare" or which "will impair to a significant degree the performance of any emission control device or system . . . in general use." Section 211(g) of the Act authorizes the Administrator to promulgate "such regulations as he deems appropriate with respect to the reduction of the average lead content of gasoline refined by small refiners on or after October 1, 1982," subject only to the condition that he "take into account" experience under the small refinery sliding scale standards mandated by the statute prior to that date.

EPA's authority to control usage of lead as an additive in gasoline under section 211(c)(1)(A) to protect public health is well-established, and prior regulations significantly curtailing lead additive usage have been upheld in court. *Ethyl Corp. v. EPA*, 541 F.2d 1 (D.C. Cir. (en banc)), cert. denied, 426 U.S. 941 (1976); *SRTF v. EPA*, *supra*. On review of the current regulations, the Court of Appeals for the District of Columbia Circuit concluded that [illegible] "between gasoline lead and blood lead"

[1] The Agency also published technical corrections to the October 29, 1982, final rules on the same date. 48 FR 5727.

[2] On March 31, 1983, the Agency announced its enforcement policy concerning the interim standards and its interpretation of the inter-refinery averaging provision (at 40 CFR 80.20(d)(1)(i)) in light of different compliance periods for large and small refineries. 48 FR 13428.

and a "significant risk of adverse health effects" even from relatively low blood lead levels, any reduction in gasoline lead necessarily reduces the risk from lead to the public health. *SRTF* v. *EPA*, EPA 705 F.2d at 531.

In deciding whether to restrict fuel additives such as lead under section 211(c)(1)(A), the Administrator is required by section 211(c)(2)(A) to "consider" all relevant scientific and medical evidence available to him. The Agency has considered all such information in developing the current proposal, as described in Part III.C of this notice.

Similarly, before restricting an additive under section 211(c)(1)(B)—to prevent damage to emission control systems—the Administrator is required by section 211(c)(2)(B) to consider available scientific and economic data, including a cost-benefit analysis comparing emission control devices which are (or will be) in general use that require such protection to those that do not. The Agency has considered these data in the regulatory impact analysis that has been placed in the rulemaking docket (see Part VII.A, below). Since EPA has determined that there are not (and will not be in the foreseeable future) emission control devices in general use for gasoline-powered vehicles that do not require protection from lead contamination, the cost-benefit analysis called for in section 211(c)(2)(B) cannot be performed.

In addition, if requested by a manufacturer of motor vehicles, engines, fuels or fuel additives, the Administrator must hold a public hearing on the regulations proposed under section 211(c)(1)(B), and publish his findings with respect to the issues he is required to consider under this provision at the time of promulgation of final regulations. As indicated above, EPA will hold a public hearing on the proposed regulations, and findings on the required issues will be made at the time of final rulemaking.

Finally, before prohibiting use of any fuel additive altogether, the Administrator is required by section 211(c)(2)(C) to find that such a prohibition will not result in the use of other fuel additives that will endanger the public health or welfare to the same or greater degree than the additive being prohibited. Since EPA is requesting comments on whether it should ultimately prohibit the use of all lead in gasoline, EPA has evaluated this issue in Part VI.C, below.

Comments by interested parties on the findings that must be made and information that must be considered under these provisions are requested.

III. Basis for Current Rulemaking Actions

A. Magnitude of Fuel Switching and Impact on Lead Usage and Vehicle Emissions

The use of leaded gasoline in vehicles designed and certified by EPA to use only unleaded gasoline, termed "fuel switching" or "misfueling," is of major concern to the Agency. Misfueling can occur by removing or damaging the nozzle restrictor installed in the fuel filler inlet of a vehicle equipped with a catalytic converter, by using an improper size fuel nozzle, or by funneling leaded gasoline into the gas tank. Sometimes gasoline retailers sell gasoline that is mislabeled or contaminated, but this accounts for less than one-half of 1% of misfueling. It is believed that the motivations for intentional misfueling are attempts to save money and/or to improve vehicle performance, since leaded regular gasoline is cheaper and higher in octane than unleaded regular gasoline. This practice is of great concern to the Agency both because it results in greater use of lead in gasoline, as discussed in Part III.B of this notice, and because leaded gasoline poisons catalytic converters and thereby causes very large increases in several pollutants, as discussed below.

The 1982 EPA motor vehicle emissions tampering survey (the most recent compiled by the Agency) has quantified this problem, based on inspections for three indicators of such fuel switching: the removal of the vehicle's filler inlet restrictor, the presence of leaded gasoline in the tank, and the detection of lead deposits on the tailpipe by a lead sensitive "Plumbtesmo" test paper. EPA considers the vehicle to be misfueled if any of these indicators is observed. In the 1982 tampering survey, the unadjusted average fuel switching rate was 10.6% of vehicles designed for use of unleaded gasoline. The survey covered ten sites: five in areas with inspection/maintenance (I/M) programs, and five in areas without such programs. The fuel switching rate was 6.2% in I/M areas and 15.1% in non-I/M areas, based on 2637 vehicles comprising model years 1975 through 1982. Adjusting the fuel switching rates to account for the relative percentages of vehicles in I/M and non-I/M areas results in an estimated national fuel switching rate of 13.5% of unleaded-designed vehicles.

Misfueling rates apparently vary by the ages of vehicles, by whether the vehicles are in localities that have inspection and maintenance (I/M) programs (17–18% of the light-duty fleet were in I/M areas at the time of the 1982 survey), by whether they are part of a commercial fleet, and by other factors. Table 1 provides 1982 misfueling rates by model year of vehicle and I/M status.

TABLE 1.—1982 MISFUELING RATES BY AGE OF VEHICLE AND BY I/M STATUS

Model year	In percentage		
	Overall misfueling rates	I/M areas	Non-I/M areas
1982	5.2	4.4	6.3
1981	7.5	4.3	9.6
1980	8.1	5.7	10.1
1979	12.1	4.9	20.3
1978	12.2	5.9	19.5
1977	12.4	9.9	16.5
1976	14.5	9.6	20.2
1975	17.7	6.3	30.9
Weighted average [1]	13.5	6.2	15.1

[1] This weighted average does not take into account the number of miles driven by each model year. Taking this factor into account, the weighted average is 12.2%.

The EPA survey probably underestimates real misfueling rates. One of the main reasons for this is that in this survey vehicle inspections for misfueling are voluntary, which might bias the results downward. In some areas, the rates of driver refusals of inspections were very high, ranging from less than 1% to 8% in I/M areas, and from 3% to 44% in non-I/M areas.

The increase in tailpipe emissions of pollutants other than lead due to fuel switching is quite high. The catalytic converter, responsible for the major portion of reductions in vehicle emissions, is disabled and vehicle emissions increase significantly. EPA has recently estimated the increase in emissions due to the repeated misfueling (5–10 tankfuls) of a vehicle that has an intact catalyst. For vehicles with oxidation catalysts, average emission increases are 2.47 grams per mile (gpm) for hydrocarbons (HC) and 20.96 gpm for carbon monoxide (CO), an increase in each of these pollutants of over 300% compared to a properly tuned vehicle. Vehicles equipped with a three-way converter will have estimated increases for three tailpipe pollutants: 1.57 gpm for HC, 11.30 gpm for CO, and 0.76 gpm for nitrogen oxides (NO_x). These increases, which are due solely to misfueling and not to any other form of tampering, represent an approximately 500% increase in HC, an approximately 300 percent increase in CO, and an over 100% increase in NO_x compared with the emissions of properly fueled vehicles.

The Agency currently is taking several measures to combat fuel switching and its resulting impact on emissions and lead usage. These measures include the vigorous enforcement of the misfueling regulations at gas stations and fleet facilities, the allowance of state implementation plan credits for anti-tampering and anti-misfueling programs, and a multi-media public information campaign. Despite these efforts, misfueling is expected to persist as long as leaded gasoline with a higher octane rating and a lower price than unleaded gasoline remains available on the market.

B. Current Lead Usage

Lead usage under the current 1.10 grams of lead per leaded gallon (gplg) standard has been significantly higher than that anticipated in projections included in the October 27, 1982, notice of final rulemaking. 47 FR 49329. As shown in Table 2, total lead usage during 1983 was 51.83 billion grams, 4.87 billion grams or 10.4% more than that predicted by the Agency. The major portion of this increase occurred in the third and fourth quarters, when actual lead usage exceeded projections by 3.80 billion grams, or 17.4%. This excess lead usage over EPA's 1982 projections does not result from widespread exceedances of the standard by refineries or importers, since the national average lead content of gasoline during this period was 1.09 gplg. Rather, it appears to result from differences between projected and actual total and leaded gasoline demand figures. Total gasoline demand during 1983 exceeded the projections by 6.4%. Moreover, the portion of the total demand that was for leaded gasoline failed to decline as quickly as the Agency expected. In the fourth quarter of 1983 (the last reporting period for which data are currently available), the leaded share of the market was 45.2%, about 10% higher than the 41.1% share projected by EPA in 1982. This higher-than-expected lead usage results from a combination of factors, including improper use of leaded gasoline in newer vehicles certified for use of unleaded gasoline only, more total gasoline demand than expected, and longer retention and greater use of older vehicles that may legally use leaded gasoline.[3]

TABLE 2.—PROJECTED AND ACTUAL GASOLINE AND LEAD USE UNDER CURRENT REGULATIONS

Quarters in 1983	Total gasoline demand (bil. gal.)		Percent leaded		Total lead (bil. gm.)		
	Projected	Actual	Projected	Actual	Projected	Actual	Percent difference
I[1]	24.40	24.35	45.6	46.8	12.78	12.42	−2.9
II[1]	24.15	25.73	44.1	47.2	12.27	13.70	+11.7
III	23.80	27.23	42.6	46.3	11.21	13.64	+21.7
IV	23.65	25.28	41.1	45.2	10.70	12.07	+12.8
1983 (total)	96.10	102.59	43.4	46.4	46.96	51.83	+10.4

[1] Total gasoline demand, the percentage of demand that was leaded, and total lead usage for the first two quarters are partially based on estimates. This was necessary because compliance periods under the regulations did not always coincide with calendar quarters: small refinery compliance periods were November 1, 1982, to January 31, 1983, and February 1, 1983, to June 30, 1983; non-small refinery (and importer) compliance periods were November 1, 1982, to March 31, 1983, and April 1, 1983, to June 30, 1983. In developing these estimates, EPA assumed that during compliance periods that did not coincide with calendar quarters (i.e., both small refinery and the first non-small refinery compliance periods), gasoline demand and lead usage were divided equally among the months in the periods.

C. Health Effects of Lead in Gasoline

1. 1982 Rulemaking

For the 1982 lead phasedown rulemaking, EPA examined the existing health evidence and made findings and conclusions which largely formed the basis for the final rule. As part of this proposal, the Agency has reexamined those findings and conclusions in light of newly published information and reanalysis of previous data, which has enabled EPA to make a better assessment of the health effects, with particular attention to the relationship of leaded gasoline and human health effects.

The entire discussion of the analysis leading to the previous findings and conclusions is not repeated in this notice, as they essentially are being reaffirmed, but can instead be found in the preamble to the 1982 proposed regulations (47 FR 38070) and in the document, "Supplemental Response to Comments on the February 22, 1982, and August 27, 1982, Proposals to Amend the Gasoline Lead Content Regulations," ("Response to Comments") submitted to the 1982 docket (A–81–36) at the time of final rulemaking. However, the main conclusions reached in 1982 are an important reference point for further discussion, and they are summarized as follows:

(1) EPA concluded that environmental lead exposure is a national health problem. In particular, EPA was concerned about elevated blood lead levels in young children.

(2) EPA concluded that gasoline lead is a major source of lead exposure, accounting for 90% of total airborne emissions and contributing significantly to non-air pathways of exposure, e.g., ingestion of dust and dirt lead. In addition, the Agency found that gasoline lead usage is correlated with blood lead levels.

(3) EPA concluded that the evidence available at that time on neurological effects at low blood lead levels tended to confirm the Agency's judgment on the need to take all reasonable steps to control lead emissions (47 FR 38077).

Based on this rationale, EPA concluded that it should adopt more stringent gasoline lead content regulations. In this notice current information on this subject area, including new studies, will be examined within the context of this regulatory rationale.

In a separate proceeding, EPA is undertaking a review of the national ambient air quality standards (NAAQS) for lead and the air quality criteria document for lead, as required by sections 108 and 109 of the Clean Air Act, 42 U.S.C. sections 7408 and 7409. See 49 FR 22021 (May 24, 1984). This review process involves extensive public comment, public meetings, and scientific and medical reviews by the Clean Air Scientific Advisory Committee of EPA's Science Advisory Board (SAB). The medical significance of the new studies discussed in this notice and related health effects are also under review by the SAB as part of that process. Because the NAAQS review process is very elaborate and time-consuming, it is unlikely to be concluded soon. Although the process may shed further light on some of the issues discussed in this notice, particularly with regard to low-level effects of lead, EPA believes it is unnecessary and would be inappropriate to defer further action to reduce the use of lead in gasoline until the NAAQS review is concluded. See *SRTF* v. *EPA*, *supra*, 705 F.2d at 516–518. The rationale for today's proposal is unlikely to conflict with any plausible outcome of the NAAQS review, and any delay in reducing gasoline lead usage would unnecessarily reduce the benefits sought to be achieved by this proposal. As in the 1982 rulemaking, conclusions reached in this proceeding will be based on EPA's current assessment of available information, including any preliminary results of the NAAQS review process, and are not intended to preempt or prejudge further aspects of

[3] A portion of the excess lead usage in the second quarter of 1983 is also attributable to the replacement of the 1.90 gplg small refinery standard with standards of 2.15 gptg and 2.65 gptg, as discussed in Part I.D. of this notice.

the NAAQS review process, including any findings or recommendations of the SAB.

2. *Exposure to Environmental Lead as National Health Problem*

Since the 1982 rulemaking, new information has become available that confirms and reinforces EPA's previous conclusion that there is a national health problem associated with exposure to environmental lead for the general population and, in particular, pre-school children. The Centers for Disease Control (CDC) of the U.S. Department of Health and Human Services are also concerned about this problem. An open meeting of the CDC Childhood Lead Poisoning Prevention Advisory Committee was held on May 17–18, 1984. The recommendation of this Committee is to lower the definition of elevated blood lead level from the current 30 micrograms per deciliter (μg/dl) to 25 μg/dl and to consider elevated blood lead levels combined with erythrocyte protoporphyrin levels above 35 μg/dl as evidence of lead toxicity. This recommendation is under review by the Department of Health and Human Services, whose Secretary must approve any change in the definition. An elevated blood lead level reflects an undue absorption of lead warranting medical action to reduce a child's blood lead level. EPA is also becoming concerned about health effects newly reported to be associated with lower level lead exposures (at blood lead levels below 30 μg/dl). These effects are discussed in Part III.C4 of this notice.

In addition, as discussed above, with the current rate of misfueling, prior projections of lead usage in gasoline are inaccurate. For example, the 1982 rulemaking predicted that lead usage in 1988 would be 21.4 billion grams, but estimates for 1988 which incorporate current misfueling rates amount to 35.7 billion grams, 67% more than previously anticipated. Because of the relation between gasoline lead usage and blood lead levels, as discussed below, this unexpectedly high level of lead usage would result in more cases of elevated blood lead levels (>30μg/dl) in young children than previously anticipated.

In conclusion, because of the Agency's existing concerns about lead exposure (particularly by pre-school children), its increased concern about low lead level effects, and a slowing of expected progress towards reducing lead usage, the only prudent conclusion is that a serious public health problem still exists.

3. The Relationship Between Gasoline Lead and Blood Lead Levels

In the 1982 rulemaking, EPA reviewed the studies submitted to the docket on the issue of whether gasoline lead was a contributor to blood lead levels. 47 FR 38074–38076. These studies consisted of various statistical analyses of population blood lead data and various indicators of gasoline lead consumption (Sinn 1980, 1981; billick 1982a, 1982b, 1980, 1979; EPA/ICF 1982; NCHS/CDC 1982; Oxley 1982). A full discussion of the EPA analysis of the strengths and weaknesses of these studies can be found in the preamble to the August 27, 1982, proposal (47 FR 38070) and in the Response to Comments. EPA used these analysis in deciding to further regulate lead in gasoline. EPA's conclusion was that environmental exposure to lead from gasoline is a significant contributor to total lead exposure of the public. While some of the statistical analyses had some methodological flaws, EPA was convinced that they provided an important qualitative indicator of the contribution of gasoline lead to total lead exposure, However, because of the problem of unaccounted variation in other source variables, any quantitative use of these analyses was made with caution.

a. *Analysis of Gasoline Lead/Blood Lead Relationships Involving NHANES II Data.* As part of the NAAQS review process, an expert review group was convened by the Agency to examine several studies that used data from the National Center for Health Statistics (NCHS) Second National Health and Nutrition Examination Survey (NHANES II) in determining blood lead/gasoline lead relationships. The final report of the review group has been submitted to the docket of this proceeding. The following specific studies were examined:

(1) An Ethyl Corporation analysis (two documents, dated May 14, 1982, and October 8, 1982, submitted to the docket of the 1982 rulemaking) found no evidence of associations between blood lead and gasoline lead.

(2) Two EPA consultant analyses, one by ICF, Inc., and one by Energy and Resource Consultants, Inc. (EPA analyses), found a clear relationship between gasoline lead and blood lead.

(3) A CDC/NCHS analysis (dated February 26, 1983) and a series of related appendices found a clear relationship between gasoline lead and blood lead.

After reviewing these analyses, the review group concluded:

(1) Two variables used by Ethyl to describe gasoline lead use, population density and gasoline use per unit area, led to a signficant difference between the Ethyl analysis and the other studies examined. The review group deemed these variables to be inappropriate and concluded that the Ethyl analysis contributed little to understanding the gasoline lead/blood lead relationship.

(2) The NHANES II data can be used for time trend analysis, and the magnitude of blood lead changes over time can be estimated. Care should be taken in interpreting changes in blood lead levels over time due to sampling error, measurement error, non-response rate and the need to adjust for time-related imblance in the survey design.

(3) The EPA and CDC analyses demonstrate a strong correlation between gasoline lead usage and blood lead levels. In the absence of scientifically plausible alternative explanations, the hypothesis that gasoline lead is an important causal factor for blood lead levels must receive serious consideration. Despite this strong relationship, the NHANES II survey and the analyses do not confirm the causal relationship. Rather, the finding of a correlation is based on the qualitatively consistent results obtained from extensive analyses done in different but complementary ways.

(4) The results of the EPA and CDC/NCHS analyses have been used to quantify the effect of gasoline lead on blood lead levels. The review group found that such inferences required strong assumptions about the absence of effects from other unmeasured sources of lead (principally lead paint and dietary lead), the adequacy of national gasoline lead usage as a proxy for local lead exposure, and the adequacy of a cross-sectional sample design. The adequacy of these assumptions could not be determined by the panel. Further, the review group cautioned against extrapolations beyond the time period of the NHANES II sampling period (1976–1980).

b. *Additional Studies of the Gasoline Lead/Blood Lead Relationship.* Several new studies on the relationship of gasoline lead to blood lead levels have become available since the 1982 rulemaking. These studies include the following:

(1) An updated report of the Italian Lead Isotope Study (Facchetti and Geiss 1982) was designed based on the fact that non-radioactive isotopes of lead are stable. By examining the varying proportions of isotopes present in the blood and in environmental samples, the source of the blood lead can be determined. In this study, the isotope ratio of lead in gasoline in Northwest

Italy was altered and the contribution of gasoline lead to blood lead levels was analyzed by monitoring the lead isotope ratio in blood lead. The results to date show that from 3 to 5 μg/dl of the blood lead in adult males came from gasoline lead. This study clearly demonstrates gasoline lead uptake by adult males and confirms an earlier study in Dallas (Manton 1977; Stephens 1981).

(2) The published version of the CDC/NCHS studies (Annest 1983) reports the same conclusions as the earlier analyses examined by the NAAQS time trend review group (see Part III.C.3.a., above).

(3) An EPA study (Schwartz, Pitcher and Janney 1983) examined the blood lead/gasoline lead relationship using three different blood lead data bases—NHANES II, CDC blood lead screening data, and Chicago Health Department blood lead data. This study, an expansion of that reviewed by the NAAQS time trend review group, was done specifically to address issues of causality and potential confounding factors. It does not differ in results from the earlier version. The study found a strong relationship between blood lead and gasoline lead for each blood lead data base. In analyzing the Chicago blood lead data, the study also found that reduced paint lead exposure did not confound the relationship between blood lead and gasoline lead because the relationship was significant ever for children who lived in houses with no lead paint. Moreover, the EPA study found that the coefficient of gasoline lead influence on blood lead in the Chicago data was virtually identical to the coefficient in the NHANES data, after adjusting for the proportion of national gasoline sold in Chicago. The study also analyzed adults separately and found the same effect, which again indicates that paint lead is not a confounding factor since adults do not eat paint chips. A supplementary paper (Schwartz 1984) shows that changes in lead solder used in cans (the most significant source of lead in canned foods) does not confound the blood lead/gasoline lead relationship.

(4) A study on umbilical cord lead (Rabinowitz and Needleman 1983) showed a strong relationship between gasoline lead and umbilical cord lead levels in Boston.

c. *Conclusions.* After reexamining the previously available information, as well as new information, EPA concludes that its previous finding that there is a relationship between gasoline lead usage and blood lead levels is still valid. In addition, EPA also believes that while some of the earlier cautions on the use of certain data to support this correlation are still appropriate, the diversity of analyses that continue to produce consistent results allows the Agency to place more confidence in these studies with respect to their usefulness in the development of regulatory options.

Specifically, the Agency finds that the studies provide strong evidence demonstrating the existence of a relationship between gasoline lead and blood lead levels. This information supports EPA's existing position that from a national health standpoint, the rapid reduction and eventual end to the use of lead in gasoline is an appropriate objective.

As discussed in Part V.C of this notice, EPA has used relationships between gasoline lead and blood lead levels to estimate the numbers of incidences of children's blood lead levels exceeding 30 μg/dl (and other blood lead levels) that would be prevented by the proposed 0.10 gplg standard. Since the number of children with blood lead levels of 30 μg/dl or higher is a major health concern, regulatory options have been analyzed with respect to mitigating the incidences of such blood lead levels. EPA has used the quantitative results of these new analyses in examining various regulatory alternatives and impacts, such as the impact on blood lead levels of children as gasoline lead levels are varied, and EPA expects to consider these results in formulating any final rule. Specific comment is requested on this approach to the use of these studies and this type of analysis.

4. Effects of Elevated Blood Lead Levels

In the process of setting the current NAAQS for lead in 1978, EPA defined a blood lead level of 30 μg/dl as the maximum safe individual blood lead level for children. This determination was in agreement with the 1978 CDC definition of 30 μg/dl as the screening criteria level for undue lead exposure in children. This was a screening level established by CDC in order to avoid unacceptable risks from certain lead-induced health effects. As indicated above, the CDC is reevaluating the 30 μg/dl criteria level and an expert advisory committee has recommended lowering the level to 25 μg/dl.

The list of demonstrated health effects at blood lead levels exceeding 30 μg/dl is well-established. The existing air quality criteria document for lead (1978) and the first external review draft of a revised criteria document (1983) contain excellent summaries of such effects, which include: (1) Death due to lead encephalopathy and renal dysfunction at blood lead levels of 80+ μg/dl; (2) frank anemia, anorexia, abdominal pain, and vomiting at 70 μg/dl; (3) reduced hemoglobin, cognitive/central nervous system (CNS) deficits and slowed nerve condition velocity at 40 μg/dl; and (4) vitamin D metabolism interference at 30+ μg/dl.

While there is much debate about neurological effects in children at low blood lead levels (<30 μg/dl), there is better evidence of such effects at elevated levels. The De la Burde and Choate studies (1972, 1975) are examples of several studies providing evidence of neurological effects in non-overtly lead intoxicated children. These studies found (at levels of 30+ μg/dl) significant fine motor and neurological dysfunctions, impaired concept formation, lower IQ, and altered behavior among 70 pre-school children. The follow-up study indicated significant CNS impairment for the lead-exposed group, in addition to a greater incidence of this group being required to repeat a grade in school or being referred to the school psychologist for behavior problems. Other studies (e.g., Needleman et al. (1979) and the recently conducted reanalysis of that study's data set) also provide results qualitatively indicative of likely IQ effects at blood lead levels in excess of 30 μg/dl.

Among the variety of biochemical effects seen at blood lead levels approaching or exceeding 30 μg/dl is the effect of lead on vitamin D metabolism. Rosen et al. (1980, 1981) and Mahaffey et al. (1982) have shown a negative correlation between the active vitamin D metabolite and blood lead levels in children across a range of 33–120 μg/dl. Reductions in vitamin D levels are associated with both (1) reduced absorption and utilization of calcium and other essential elements crucial for normal growth and development; and (2) a concomitant increased uptake of lead, thus creating an adverse interactive cycle of increasingly greater lead absortion/retention as a function of reduced vitamin D metabolism as blood lead level increase.

5. Low Level Lead Effects

a. *Introduction.* Effects from low level lead exposure on biochemical, hematological, neurological, and other systems are known to exist. For purposes of this proposal, low level effects are considered to be those observed to occur at blood lead levels less than 30 μg/dl. The importance of these effects was examined in the 1982 rulemaking, in which EPA made two findings concerning low level effects. First, EPA found that there is a continuum of effects from low level lead exposures related to biochemical changes to death at high exposures. Second, EPA focused on neurological effects due to low level lead exposures and concluded that such effects could only be judged qualitatively, but were supportive of EPA's decision to take all reasonable steps to reduce lead emissions. 47 FR 38077 (August 27, 1982). In addition to the neurological effects associated with low level lead exposures on which EPA primarily focused in the 1982 rulemaking, the Agency now believes that other low level effects are also of concern and should be taken into account in any further rulemaking actions regarding gasoline lead.

b. *Pathophysiological Effects.* Based on several summaries of the scientific and medical literature (e.g., National Academy of Sciences (1980); EPA Air Quality Criteria for Lead (1978), (1983 external review draft); EPA Draft Cost/Benefit Analysis (1984)), it is reasonable to conclude that there exists and apparent continuum of pathophysiological effects associated with low level lead exposure. This continuum is illustrated by the following effects:

(1) Inhibition of pyrimidine-5'-nucleotidase (PY-5-N) observed to begin at 10 μg/dl of blood lead (Angle et al. 1982);

(2) Inhibition of delta-aminolevulenic acid dehydrase (ALA-D) activity (50% at about 16 μg/dl) (Hernberg and Nikkanen 1970);

(3) Elevated levels of zinc protoporphyrin (ZPP or FEP) in red blood cells (erythrocytes) at about 15 μg/dl (indicative of a general interference in heme synthesis in the body) (Piomelli et al. 1977);

(4) Changes in electrophysiological responses (e.g., altered slow wave EEG patterns or increased latencies for brainstem auditory evoked potentials) indicative of central nervous system dysfunction, starting at about 15 μg/dl, and altered peripheral nerve conduction velocities evident at similar or somewhat higher blood lead levels (Otto et al. 1981, 1982; Benignius et al. 1981; Landrigan et al. 1976).

(5) Increased levels of aminolevulenic acid (ALA) at levels of 15 μg/dl or lower (Meredith et al. 1978);

(6) Inhibition of vitamin D pathways detected at levels as low as 10–15 μg/dl with possible enhanced inhibition and lead absorption as blood lead levels increase (Rosen et al. 1980, 1981; Mahaffey et al. 1982); and

(7) Inhibition of globin synthesis beginning at about 20 μg/dl (White and Harvey 1972; Dresner et al. 1982).

The medical significance of these pathophysiological effects is not yet fully understood, although further insights may be developed during the NAAQS review process. However, the deleterious nature of such effects and the vital nature of the affected physiological functions suggest potential public health benefits associated with mitigation of these effects through action on gasoline lead content.

c. *Additional Effects of Potential Concern.* As part of the NAAQS review process, EPA and the SAB are evaluating a number of newly available studies that raise additional potential concerns at lead levels below 30 μg/dl. These studies, which will also be considered by the Agency in this rulemaking, include:

(1) *Hematological Effects.* EPA's draft cost/benefit analysis (1984, Chapter VI.B) reports significant correlations between hematological effects indicators and blood lead levels below 30 μg/dl.

(2) *Fetal Effects.* Needleman et al. (1984) reports a significant association between congenital anomalies and umbilical cord blood lead levels. Erickson et al. (1983) reported an association between lung and rib lead levels and Sudden Infant Death Syndrome (SIDS).

(3) *Neurological Effects.* McBride et al. (1982), Yule et al. (1981), Smith et al. (1983), Yule and Landsdowne (1983), Harvey et al. (1983), and Winneke et al. (1982), all examined cognitive (IQ) and other behavioral effects from low level lead exposure and found variable results that, collectively, suggest possible small effects on IQ and/or other behavioral dysfunctions.

While there is much controversy surrounding the interpretation of many of these individual studies, and care must be exercised in drawing firm conclusions from them, EPA believes that the aggregate results of these studies are suggestive enough of low level effects of lead to cause concern that lead exerts such effects on human populations, especially children.

d. *Conclusions on Low Level Effects.* EPA tentatively concludes that evidence exists for some types of neuro-psychological effects due to low level lead exposure among children. Other effects, e.g., interference with vitamin D metabolism, have been more clearly demonstrated at blood lead levels below 30 μg/dl and are of much concern to the Agency. While today's proposal is not based solely on low level effects, in the development of a final rule EPA intends to consider, absent compelling information to the contrary, the mitigation of these effects to be a significant health benefit.

6. Conclusion

After a thorough review of the 1982 rulemaking and new information that has been made available, EPA reaffirms its original rationale for regulating lead in gasoline. It is the Agency's opinion that a national health problem still exists with regard to environmental lead, that gasoline lead is a major contributor to lead exposure, that lead emissions should be controlled to the extent possible, and that all reasonable efforts should be taken to reduce lead exposure to the population as rapidly as possible.

In addition, it is the opinion of the Agency that there is no health-based reason to continue the use of lead in gasoline, as this is the most readily controlled and most ubiquitous source of lead emissions into the environment. A prudent health objective is the rapid reduction and eventual end to the use of lead in gasoline.

As noted above, this conclusion is consistent with the Court of Appeals decision upholding the 1982 regulations, which stated that "the demonstrated connection between gasoline lead and blood lead, the demonstrated health effects of blood lead levels of 30 μg/dl and above, and the significant risk of adverse health effects from blood lead levels as low as 10–15 μg/dl, would justify EPA in banning lead from gasoline entirely." 705 F.2d at 531.

IV. EPA Proposed Actions

A. Gasoline Lead Content Standards

1. 0.10 gplg Standard

In promulgating the current gasoline lead content standard of 1.10 gplg, the Agency concluded that there was a continued need for control of lead in gasoline and that further action to reduce lead in gasoline was needed to protect the public health. 47 FR 49330. For the period 1983–90, the Agency predicted that the 1.10 gplg standard would result in approximately 34% less lead usage in gasoline than would have occurred under the former regulations. 47 FR 49329. Promulgation of a leaded gasoline-only standard was expected to result in such an accelerated reduction in lead usage because the market share of leaded gasoline was predicted to shrink rapidly over this period (from 43% in 1983 to 18% in 1990) due to the replacement of older vehicles with newer vehicles designed for unleaded gasoline. Under this regulation, reductions in lead usage are dependent on a decreasing demand for leaded gasoline.

As noted above, however, gasoline lead usage is not being reduced as rapidly as expected by the Agency. A major reason is the widespread occurrence of fuel switching, which is presently found in about 13.5% of vehicles designed for unleaded gasoline. Use of leaded gasoline in such vehicles poisons their catalytic converters, causing a substantial increase in HC, CO and NO_x emissions. Such increased use of leaded gasoline also results in increased tailpipe lead emissions. Fuel switching at the rate found today is likely to cause an indefinite general demand for leaded gasoline. For example, misfueling is predicted to account for close to 40% of the demand for leaded gasoline by 1990.

In addition, as also noted above, EPA's latest review of available information on the health implications of lead usage confirms and reinforces its previous conclusion that the public health is endangered through the continued use of lead in gasoline. EPA has also developed information on the public health benefits of removing lead from gasoline, in terms of reduced blood-lead levels, reduced lead-related medical costs, and reduced adverse effects of other pollutants (ozone, CO, HC and NO_x). These benefits are described in Part V of this notice, along with other benefits of the proposed regulations.

Because of its effect on motor vehicle catalytic converters and its impact on public health, the Agency would like to reduce and ultimately eliminate the use of lead in gasoline as quickly as feasible. EPA believes that the refining industry may be able to produce all unleaded gasoline as early as 1986. However, such an action could have an adverse impact on older automobiles, as well as certain trucks and other vehicles, as described below. In order to prevent this impact, the Agency at this time is proposing a leaded gasoline standard of 0.10 gplg, effective January 1, 1986. This would result in a 91% reduction in the allowable amount of lead in each gallon of leaded gasoline and should significantly reduce the adverse impacts of lead on public health, as well as reduce a large percentage of the HC, CO and NO_x emission increases due to fuel switching. Further, the Agency is requesting comments on a "no-lead" standard to be effective on January 1, 1995, as discussed in Part IV.A.3 of this notice.

The proposed standard of 1.10 gplg is intended to provide the minimum amount of lead needed to prevent valve-seat recession in older automobiles, certain trucks and other vehicles. In many older engine designs, cylinder heads are made of cast iron. In these engines, exhaust valve seats are ground directly into the cylinder head itself without special surface treatment. Under high temperatures, loads or speeds, use of fuel in such engines that does not contain some amount of lead or other additive may result in valve-seat recession or abnormal valve-seat wear. Lead compounds produced by combustion of fuel containing such additives form deposits on the valve-seat, producing an anti-welding, lubricating film between the valve-seat and face during engine operation. Valve-seat recession causes leaking valves, loss of compression pressure in the cylinders, degraded vehicle performance, and significant increases in hydrocarbon emissions.

EPA estimates that in 1986 there will be about 20.5 million light-duty vehicles (automobiles) and light-duty trucks on the road that may require use of a fuel containing some amount of lead or other additive to protect against valve-seat recession. In 1971, vehicle manufacturers began to take steps to prevent valve-seat recession in anticipation of the widespread use of unleaded gasoline. Valve-seats in cast iron cylinder heads have been induction-hardened or surfaced with a particularly hard metal, such as nickel. General Motors Corporation (GM) (which had a market share of about 50%) began to make these improvements on all of its light-duty vehicle engines in 1971. After that date, other manufacturers phased in these changes and since the 1975 model year, essentially all light-duty vehicles and light-duty trucks under 6000 pounds gross vehicle weight (GVW) have been treated so that they may run on unleaded gasoline. Light-duty trucks between 6000 and 8500 pounds GVW are assumed to have been treated to run on unleaded gasoline since the 1979 model year.

In addition, many of the approximately ten million heavy-duty gasoline-fueled trucks (greater than 8500 pounds GVW) expected to be on the road in 1986 will be able to run on unleaded gasoline (e.g., Ford and Chrysler vehicles). However, a portion of heavy-duty trucks (e.g., GM vehicles), as well as a portion of other engines such as motorcycles, boats, and gasoline-powered equipment, may need a valve lubricant such as lead in 1986.

EPA has examined the available studies on the amount of lead needed to protect against valve-seat recession, which are summarized in a January 16, 1984, memorandum that has been placed in the docket. The minimum lead level sufficient for this purpose, as reported in the literature, ranges from "more than 0.03 grams per gallon" (gpg) to 0.50 gpg. In evaluating these studies, EPA has given the most weight to the Doelling (1971) study, which is the only analysis that had as an objective the determination of the minimum lead level needed to prevent valve-seat recession. In this study, tests were conducted at lead levels, recession was not found, while at 0.04 gpg it was experienced. Thus, Doelling concluded that between 0.04 and 0.07 gpg was needed to protect against valve recession. A similarly low amount of lead as the minimum amount needed for this purpose was also found by Giles (1971), who concluded that less than 0.03 gpg led to valve-seat recession, and by Pahnke and Conte (1969), who concluded that gasoline containing 0.10 gpg was adequate to prevent this problem. EPA has placed less weight on other studies which cite higher levels of lead as being necessary, since these were not designed to determine the minimum amount of lead needed to prevent valve-seat recession. In particular, studies which concluded that 0.50 gpg is needed for this purpose may have been affected by the knowledge that the first 0.50 gpg of lead provides a large octane boost.

Since the minimum amount of lead needed to prevent valve-seat recession has not been precisely determined, EPA is proposing a standard of 0.10 gplg. This level is supported by the three studies cited above, all of which found such a lead level adequate to protect against this problem. This level should assure that all engines actually receive an adequate amount of lead for this purpose.

The Agency is proposing a January 1, 1986, effective date for the 0.10 gplg standard because its analysis using the Department of Energy linear programming model (discussed in Part V.B.1 of this notice) suggests that that date is feasible for the industry as a whole and because it maximizes the net benefits of the standard. The industry would be provided approximately one year from the anticipated date of promulgation of the standard, which could allow adequate time to enter into contracts for any different types of feedstock needed to produce the low-lead leaded gasoline. Use of more light crude oil is one strategy that may be used, since such oil requires less processing at a refinery. The proposed regulation may not necessitate the construction of any additional equipment at refineries, since they are currently running at approximately 74%

of capacity. The DOE linear programming model suggests that an adequate supply of low-lead gasoline could be made by running existing catalytic crackers at full capacity and by running existing reformers at a higher severity (i.e., higher temperature and pressure), as well as by using reformers to further process some of the catalytic-cracked gasoline. Reformers would not be run at full capacity, however, since an adequate amount of naphtha usable in this process is not projected to be available. Refiners might also switch to other additives to boost octane in low-lead gasoline, which could result in lower refiner costs than the EPA estimates listed below and in Part V.B of this notice.

However, the Agency realizes that there may be problems for individual refiners in meeting a 0.10 gplg standard on January 1, 1986. Although EPA's modeling indicates the possibility of this standard for the industry as a whole, it might result in adverse impacts on some portions of the refining industry. It may also provide an inadequate margin of safety for unexpected disruptions of gasoline-producing equipment. In case comments indicate that the impact of a 0.10 gplg standard on January 1, 1986, is expected to be adverse for a substantial portion of the industry, the Agency is also considering alternative compliance schedules. Specifically, the Agency is considering promulgation of a phased-in 0.10 gplg standard (for example, a 0.50 gplg standard starting on July 1, 1985, a 0.30 gplg standard starting on January 1, 1986, a 0.20 gplg standard starting on January 1, 1987, and a 0.10 gplg standard effective January 1, 1988). The Agency believes that a 0.10 gplg standard is clearly feasible by January 1, 1988, since it would allow time for the construction of additional petroleum processing equipment. EPA also believes that incremental reductions in allowable lead usage on earlier dates should also be feasible. While such a phased-in low-lead standard would provide additional time to the industry, a rapidly-effective 0.50 gplg standard and other phased-in interim standards would still result in significant lead usage reductions and commensurate health benefits.

The Agency therefore specifically requests comments on the feasibility of a January 1, 1986, date for refiners to comply with a 0.10 gplg standard. If a refiner believes that it cannot meet that date, it should indicate by what date the 0.10 gplg standard could be met, what standard(s) could be met earlier, and what the economic impacts would be to it of a 0.10 gplg standard effective on that date. Comments on a phased-in 0.10 gplg standard, such as that outlined above, are also requested.

Although a January 1, 1986, effective date (if feasible) would not provide enough time for construction of new processing equipment (primarily isomerization units) and would therefore be somewhat more costly to the industry than if additional time were provided for such construction, the increased benefits from the earlier date would more than offset this extra cost. EPA has compared the costs and benefits of a 0.10 gplg standard effective on January 1, 1986, with those of the same standard effective on January 1, 1987, and January 1, 1988.[4] The last date would allow approximately three years for construction of isomerization units (including time needed to obtain necessary environmental permits). Total annualized costs to refiners of the 0.10 gplg standard are estimated to be $575 million in 1986, $532 million in 1987, and $503 million in 1988 (all in 1983 dollars). Most of the cost differences are due to the higher projected volume of leaded gasoline in the earlier years. Total annualized benefits for which a monetary value can be assigned (vehicle maintenance savings, conventional pollutant benefits from eliminating misfueling, and medical and educational costs that would have accrued for lead-poisoned children) are estimated to be $1,819 million in 1986, $1,710 million in 1987, and $1,604 million in 1988. Net benefits are $1,244 million in 1986, $1,178 million in 1987, and $1.101 million in 1988. Since a 1986 standard would result in net benefits in both 1986 and 1987 that would not be achieved by a 1988 standard, the net benefits of a 1986 standard would be more than $2.4 billion higher than a 1988 standard. These costs and benefits are summarized in Table 3.

TABLE 3.—COMPARISON OF ANNUALIZED COSTS AND BENEFITS OF 0.10 GPLG STANDARD: 1986–1988

[Millions of 1983 dollars]

	1986	1987	1988
Benefits:[1]			
Maintenance	840	784	737
Fuel efficiency	360	329	298
Conventional Pollutants	348	351	344
Lead (medical and educational)	271	246	225
Total	1,819	1,710	1,604
Costs (total)	575	532	503
Net benefits	1,244	1,178	1,101

[1] For a summary of the types of benefits evaluated by EPA and a discussion of how both costs and benefits were calculated, see Part V.B of this notice.

[4] An extensive discussion of the costs and benefits of the proposed standard is found in Part V.B of this notice and in the preliminary regulatory impact analysis concerning this proposal.

The Agency has also analyzed the costs and benefits of the phased-in standard outlined above (i.e., 0.50 gplg on July 1, 1985, 0.30 gplg on January 1, 1986, 0.20 gplg on January 1, 1987, 0.10 gplg on January 1, 1988). The estimated costs to refiners of such a phased-in standard for the 1985–87 period would be $833 million, while estimated total benefits would be $2,704 million. The net benefits of such a standard would, therefore, be $1,871 million for this period.

The Agency specifically requests comments on the adequacy of the 0.10 gplg standard to protect vehicle engines and on the feasibility of the effective date of the refining industry.

2. Marketing Restrictions

EPA intends that this rulemaking will eliminate or drastically reduce fuel switching by vehicle owners. The proposed standard of 0.10 gplg is intended to allow only enough lead in gasoline to prevent valve problems in certain engines, mainly in trucks and older cars. The Agency anticipates that leaded gasoline will continue to be produced at the 89 octane level ((R+M)/2) and therefore be more costly to make than unleaded gasoline produced at an 87 octane level. This would result from the fact that the blending stock for leaded gasoline would have to have greater than 88 octane prior to the addition of the allowable 0.10 gram of lead. Production of such a blending stock would by itself be more costly than production of unleaded gasoline at the lower octane level. Since leaded gasoline is expected to cost more to produce than unleaded, the Agency would hope that its retail price would reflect this cost differential and that leaded gasoline would no longer be marketed as a lower-priced "loss leader", as it is today. Thus, there would no longer be an incentive to vehicle owners to buy leaded gasoline as the least expensive grade. This would therefore eliminate the major incentive for fuel switching.

In addition, EPA will continue its aggessive enforcement program to stop fuel switching. The Agency will also continue to seek legislative authority to hold individual fuel switchers liable for their actions. States and local governments will continue to be encouraged to adopt and enforce their own anti-misfueling laws, and will be able to obtain emission reduction credits in their state implementation plans for such programs. Finally, the Agency is conducting a major public relations effort to pass the message to potential fuel switchers that such actions are not in their own best long-term interests.

Over the last year, the Agency has met extensively with representatives of environmental groups, public interest groups, the auto industry, and the various segments of the automotive fuel marketing industry to discuss the problem of fuel switching. Many suggested solutions to the fuel switching problem were received during these meetings. The one that appears to be most effective is the accelerated phasedown of lead being proposed here. Some of the other suggested solutions, however, may have merit in conjunction with the use of a low-lead leaded gasoline standard if low-lead gasoline will not be priced higher than unleaded gasoline. These additional strategies are being studied by the Agency for possible adoption in conjunction with the rule proposed today should the Agency conclude that such additional assurances against fuel switching are desirable.

To assist in determining the need for such additional measures, the Agency specifically solicits comments, both in writing and at the public hearing, from the gasoline producing and marketing industries and others as to how leaded gasoline with a lead content of 0.10 gplg would be marketed. Such comments should address the octane level at which this type of leaded gasoline would be marketed, its price relative to unleaded gasoline, other marketing practices likely to occur should EPA take final action to adopt such a lead content standard, and whether low-lead leaded gasoline would be marketed by the industry in such a way that fuel switching would be discouraged without additional regulatory measures.

The additional regulatory actions being considered by the Agency for potential adoption to discourage fuel switching include the following:

(1) EPA could focus enforcement efforts against those retailers who encourage the practice of fuel switching by violating EPA's fuel regulations. The Agency would give priority to enforcing the fuel switching regulations against those retailers who, despite the higher cost of leaded gasoline at 0.10 gplg, continue to price this product below the price of unleaded gasoline.

(2) Sale of leaded gasoline could be restricted to full-serve pumps only (i.e., only a station operator or attendant would be allowed to fill a vehicle tank with leaded gasoline). Under such a regulation, filling a vehicle (even those designed for leaded gasoline) with leaded gasoline by any other person, including a vehicle owner or operator, would be prohibited. Offering leaded gasoline at a self-serve pump would be a per se violation of such a regulation. Such a regulation could further reduce fuel switching because this practice is believed to occur more frequently at self-serve pumps than at full-serve. A recent survey by Energy and Environmental Analysis, Inc., (EEA) for EPA indicates that the fuel switching rate at full-serve pumps is less than that at self-serve pumps.

(3) The Agency could require that leaded gasoline be sold at a higher price than unleaded gasoline. Since the relative price of the two types of gasoline is believed to be the major cause of fuel switching, such a regulation could significantly reduce this practice.

(4) The Agency could institute controls of the type described in (2) above, but only at stations at which the price of leaded gasoline is lower than the price of unleaded fuel. Such a requirement could be less restrictive than either (2) or (3), while producing an equivalent result in the reduction of fuel switching.

(5) The Agency could require that leaded gasoline be produced at a specified octane level (e.g., 89 octane). Such a requirement could be expected to assure that the production costs of such leaded gasoline would be higher than that of unleaded gasoline with an 87 octane level, as explained above.

EPA specifically solicits comments on these and any other actions that could be adopted by the Agency in conjunction with the proposed low-lead standard to eliminate or reduce fuel switching.

3. No-Lead Standard

EPA's overall objective is to end the use of lead as a gasoline additive to prevent unacceptable health effects and misfueling while protecting engines designed strictly for the use of leaded fuel. In the short term we are reducing lead use by over 90%. That level will protect public health without harming vehicles in use that were designed for leaded gasoline.

In the long run, we can probably stop using lead as a gasoline additive completely since few engines designed for leaded gasoline are expected to be in use, and since we expect other additives or other approaches to be developed as a lead alternative for those remaining vehicles. These estimates, however, may turn out to be incorrect should manufacturers continue to produce vehicles which need leaded gasoline or should leaded gasoline continue to be cheaper.

EPA is proposing two alternatives relating to long term lead usage:

(a) No further regulatory action beyond the 0.10 gplg standard. We expect fewer and fewer vehicles requiring lead to be in use and this will make it more difficult to purchase low lead. Low lead will likely become more expensive as its production cost increases and demand decreases. The above trend should force the design of engines not requiring lead for these few remaining applications and should create an incentive for development of other additives and other alternatives. This trend, if it occurs, would lead to the elimination of the need for lead and hence the elimination of its use.

(b) A ban on the future use of lead as a gasoline additive, specifically by about 1995. This alternative assures that the use of lead is stopped by some specific date and hence creates a strong incentive for development of alternative engines and additives. However, it is difficult to pick a date that we can be certain provides enough time for the development of alternatives. If we are wrong, a ban could leave owners of those few vehicles needing lead with problems, if other solutions are not found.

EPA is soliciting comments on these issues and alternatives and specifically on the following items:

1. What engines are still being produced requiring lead? How quickly can designs be changed? What incentives are necessary to ensure the design changes are made?

2. What alternatives to leaded gasoline for engines designed for lead are possible; how quickly could they be developed; what incentives are necessary? What could be done to modify existing engines to run on unleaded gasoline and at what cost?

3. How many vehicles will be in use in 1995 and other dates that were designed strictly for the use of leaded gasoline?

4. Is a ban necessary to end the use of lead as a gasoline additive? if so, when should it go into effect? What should be done if alternatives are not available by that date?

5. What other alternatives are there to assure an end to the need for and use of lead as a gasoline additive?

6. If a ban is not imposed now, what should be done if lead continues to be used as a gasoline additive with resulting adverse impacts, and when?

In addition, EPA is soliciting comments on the need for the goal in terms of protecting public health and to eliminate the misfueling of vehicles.

The Agency has analyzed issues related to a ban in lead in gasoline effective in 1995. These are outlined below in subsections a, b, and c.

a. *Light-Duty Vehicles and Trucks.* As noted in Part IV.A.1 of this notice, most light-duty vehicles (automobiles) manufactured since 1971 have been designed so that they can run on unleaded gasoline. Nearly all U.S. gasoline-powered automobiles manufactured since 1975 have been certified by EPA for the use of unleaded gasoline only, and all such automobiles manufactured since 1980 have been so certified. With normal vehicle turnover, 95.2% of the automobiles on the road in 1988 will be designed to run only on unleaded gasoline. By 1995, 99.8% of automobiles will be so designed.

A comparable situation exists for light-duty trucks (8,500 pounds GVW or less). Light-duty trucks under 6,000 pounds GVW manufactured since the 1975 model year are able to use unleaded gasoline, and all other light-duty trucks manufactured since the 1979 model year also use unleaded gasoline. With normal vehicle turnover 76.0% of light-duty trucks will be designed to use only unleaded gasoline by 1988, and 98.9% will be so designed by 1995.

Therefore, the population of automobiles and light-duty trucks that will be on the road in 1995 and that will require leaded gasoline will be very small. Further, most of these vehicles will be antiques and classics that are not likely to be run under conditions (high speed and heavy load) that are most likely to cause valve damage. In addition, these vehicles will also have lead deposits already built up in the valve-seats, and vehicle that see only limited use under light load conditions may continue to be protected by this build-up.

b. *Heavy-Duty Trucks.* Many gasoline-powered heavy-duty trucks now on the road and currently being manufactured do not need lead as a valve lubricant (for example, all Ford gasoline-powered trucks on the road now can run on unleaded gasoline). Although some such trucks still require the use of lead in gasoline, all but the heaviest trucks will be equipped with catalytic converters starting in 1987 as the result of stricter emission standards, and therefore will require unleaded gasoline. See 48 FR 52170 (Nov. 16, 1983) (to be codified at 40 CFR 86.087–10). Those trucks that are not required to use unleaded gasoline by 1987 could be redesigned to do so within three to four years of the time that a band on lead in gasoline is promulgated.

Heavy-duty truck engines last for a shorter period of time than automobiles or light-duty engines. Within eight years, half of the heavy-duty engines are no longer in service. Based on this, by 1995, the agency estimates that about 80% of the heavy-duty trucks on the road will be able to use unleaded gasoline, assuming that all new heavy-duty trucks are designed to be run on unleaded gasoline by 1990. However, since truck vehicle miles traveled decrease dramatically with age, by 1995 only 4% of the vehicle miles traveled by all heavy-duty trucks will be driven by such trucks requiring leaded gasoline.

c. *Other Engines.* In addition to automobile and truck engines, there are other engines that may require lead as a valve lubricant. These include small engines (e.g., lawn mowers, chain saws, snow blowers), marine engines, farm equipment engines, and motorcycle engines. EPA knows less about the lead needs of these types of engines than it does for automobiles and trucks.

A recent survey of small engine manufacturers by EPA indicates that most of such engines now in use could use unleaded gasoline. (In fact, many manufacturers suggest unleaded gasoline as the preferred fuel to minimize engine deposits and corrosion.) On the other hand, the Agency believes that a large portion of marine engines and motorcycles are designed to use lead gasoline. Since some of these two types of engines can already use unleaded gasoline, the Agency believes that newly manufactured engines could be redesigned quickly to use this type of fuel. Since the useful life of these engines is short (approximately 5 years), most of the current engines designed for leaded gasoline would be out of use by 1995.

The Agency has been unsuccessful in obtaining specific information on smaller equipment used on farms, with the exception of gasoline-powered utility tractors, which generally have automotive-type four-cylinder engines and would be compatible with unleaded gasoline. The Agency anticipates, however, that a large portion of other farm equipment is designed to use leaded gasoline. By 1995, most of these engines requiring leaded gasoline should have been rebuilt or replaced.

B. Inter-Refinery Averaging

The gasoline lead content regulations currently provide that refiners and importers may demonstrate compliance with the 1.10 gplg standard through inter-refinery averaging via the constructive allocation mechanism. See 40 CFR 80.20(d). These provisions generally allow the allocation of lead usage from one refinery to another refinery, whether or not owned by the same refiner. The refinery to which the lead usage is allocated reports this amount (and calculates its average lead usage) as if it were actually used there, while the allocator-refinery does not include this amount of lead usage in its calculations.

The regulations proposed today would not permit use of the constructive allocation mechanism after January 1, 1986, the proposed effective date of the 0.10 gplg standard. Continuance of the averaging provision would thwart the purpose of the 0.10 gplg standard, as it would encourage the production of some leaded gasoline with lead levels that may be lower than needed to prevent valve/seat recession. If a phased-in approach is adopted, however, EPA would consider continuation of the constructive allocation mechanism until the effective date of the 0.10 gplg standard.

For the purpose of preventing contamination of catalysts, under the proposed (as well as current) standard, gasoline is required to be sold as leaded gasoline if any amount of lead is added during its production. EPA is also concerned, however, that vehicles that need lead get an adequate amount of this substance. While removal of the averaging provisions from the regulations would eliminate the major incentive to produce leaded gasoline containing lead in amounts significantly lower than allowed by the regulatory standard, there may be other incentives to do so. Because EPA is concerned that each gallon of leaded gasoline sold contain the minimum amount of lead needed to prevent valve-seat recession, the Agency requests comments on whether regulatory provisions should be modified or added to accomplish this goal. Specifically, the agency request comments on whether the present quarterly averaging period should be shortened (e.g., to a monthly, weekly, or daily averaging period). The Agency also requests comments on whether a minimum lead content standard should be established for each gallon of leaded gasoline sold by a retail outlet or used by a wholesale purchaser-consumer.

C. Other Proposed Amendments

The proposed regulations would also make several changes that the Agency believes are needed to clarify and/or simplify the gasoline lead content regulations:

(1) The definition of "unleaded gasoline" at § 80.2(g) would be amended to make clear that this type of gasoline may not include any amount of lead that has been intentionally added during its production. This change would reflect a parallel provision already contained in the definition of "leaded gasoline" at § 80.2(f). In addition, the level of

allowable lead contamination (i.e., lead that is not intentionally added by a refiner, but results during the marketing process) in unleaded gasoline would be substantially reduced, from the current 0.05 gram of lead per gallon (gpg) to 0.01 gpg. The 0.01 gpg level is currently feasible, since over 98% of the retail unleaded gasoline samples collected by an Agency contractor to date during fiscal year 1984 that met the 0.05 gpg standard did not exceed the 0.01 gpg level. In addition, the substantial reduction in the allowable amount of lead in *leaded* gasoline proposed in this notice should serve to further reduce the levels of inadvertent contaminations.

(2) The definition of a "small refinery" (§ 80.2(p)), the provisions for special small refinery standards (§ 80.20(b)), and other special provisions related to small refineries would be revoked. These provisions are no longer necessary, since both small and non-small refineries have been subject to the same gasoline lead content standard since July 1, 1983. The definition of "owned or operated" in § 80.2(q) would also be revoked, since this definition is relevant only to the small refinery definition. Other provisions that relate only to past compliance periods are also proposed to be deleted.

(3) The right of entry, test and inspection provisions in § 80.4 would be amended to clarify that they apply to the premises of an importer of gasoline.

(4) Three minor changes would be made to the importer portion of the regulations. The reporting requirements for importers (§ 80.20(c)(3)(ii)) would be amended to correct an error in the existing regulations by changing the last reference to "gasoline" in this provision to "gasoline blending stocks or components." The requirement for reporting of the name and address of any consignee of a shipment of imported leaded gasoline would be deleted as unnecessary, and a requirement for reporting the place of entry of a shipment would be added. The latter two changes affect § 80.20(c)(3)(v).

(5) A change would be made to the inter-refinery averaging provisions in § 80.20(d) to clarify the Agency's previous intent concerning this mechanism. This change would be effective starting in the first full calendar quarter after promulgation and ending in the last quarter of 1985 (after which averaging would be eliminated), and is designed to make this mechanism more workable while it is permitted to be used. A new § 80.20(d)(1)(iv) would be added to make clear that this mechanism is only available if a constructive allocation agreement is made no later than the final day of the compliance period in which the lead usage allocated was actually used. EPA notified all refiners and importers of this interpretation in a December 16, 1983, letter. The proposed change would reflect this interpretation.

V. Impact of Proposed Actions

A. Total Lead Usage

The proposed regulations would substantially reduce the amount of gasoline lead used by motor vehicles. EPA has estimated the total lead that would be used in leaded gasoline under the proposed standard of 0.10 gplg. These estimates are provided in the form of a range. Table 4 shows the estimated amount of lead usage based on two assumptions. The highest total lead usage (and hence lowest reduction) would occur if it is assumed that the proposed standard will have no impact on demand for leaded gasoline, but will simply reduce the amount of lead in each gallon of leaded gasoline. The reduction in gasoline lead for this case during the period 1986–94 would be 90.9 percent, compared to the amount of lead predicted to be used during this period under the current 1.10 gplg standard.

However, the proposed standard is also designed to deter or prevent fuel switching. Assuming that this goal is fully achieved, lead usage in gasoline would be reduced over the period 1986 through 1994 by 94.4 percent, compared to the current standard. Table 4 shows the drop in both leaded gasoline demand and lead usage that would occur if fuel switching stopped. If fuel switching were only partly eliminated, the lead usage reduction would be somewhere between 90.9% and 94.4%.

TABLE 4.—PROBABLE LEAD USAGE UNDER CURRENT AND PROPOSED REGULATIONS

Calendar year	Total gasoline (billion gals.)	Leaded demand (billion gals.)		Lead usage expected (billion grams)		
		Current projection [1]	No fuel-switching [2]	Existing Regs. (1.10 gplg)	Current demand, 0.10 gplg	No fuel-switching 0.10 gplg
1986	102.2	39.6	30.3	43.6	3.96	3.03
1987	101.7	35.3	25.3	38.8	3.53	2.53
1988	100.7	32.4	22.2	35.7	3.24	2.22
1989	100.0	29.8	19.3	32.8	2.98	1.93
1990	99.4	27.3	16.9	30.0	2.73	1.69
1991	99.1	25.3	14.8	27.8	2.53	1.49
1992	99.4	24.7	13.4	27.2	2.47	1.34
1993	100.1	24.0	12.4	26.4	2.40	1.24
1994	100.7	23.3	11.5	25.7	2.33	1.15
Total				287.9	26.17	16.61

[1] Leaded gasoline demand for this case is based on current projections and assumed to be the same under either the existing or proposed regulations.

[2] This case removes only the effect of fuel switching from otherwise projected leaded gasoline demand.

It is possible that under the proposed standard the owners of vehicles that currently legally use leaded gasoline, but do not require lead to prevent valve-seat recession problems, would choose to fuel them with unleaded gasoline. Such a scenario is possible because it is expected that the 0.10 gplg standard will cause leaded gasoline to be sold at a higher price than unleaded regular gasoline. If this were to occur, additional reductions in lead usage would result.

B. Economic Impact

EPA has analyzed the costs and the benefits of reducing the lead content of gasoline to 0.10 pglg. They are discussed in detail in the preliminary regulatory impact analysis (RIA) and in the March 1984 EPA Office of Policy Analysis draft report, "Cost and Benefits of Reducing Lead in Gasoline" ("EPA cost/benefit analysis"), both of which have been placed in the docket. The Agency has also analyzed the costs and benefits of a total ban on lead in gasoline. These costs and benefits are summarized below.

1. Refinery Costs of 0.10 gplg Standard

Lead is an inexpensive way for refiners to boost the octane of gasoline. If they are required to use less lead, they must use more expensive methods to increase the octane of their gasoline.

EPA has analyzed the increase in manufacturing costs that would occur if less lead were allowed to be used in making gasoline. Nationwide costs have been estimated using the Department of Energy's linear programming model. This model was originally developed by private consultants to the refining industry for use by the industry itself. It has been used by EPA in its study of the overall costs of environmental regulation to the refining industry, by the Department of Energy for many analyses of the refining industry, and by EPA in previous analyses of gasoline lead restrictions.

The model recently has been subject to verification testing by the Department of Energy. Given the same inputs as actually occurred in 1982, it was able to accurately predict production of the petroleum products that were made in 1982. It correctly projected the loss of products during processing that occurred in the industry, and the cost differentials it predicted between petroleum products compared well with actual price differentials at the refinery gate.

EPA also has verified the model's previous predictions of the cost of gasoline lead content regulations indirectly. In the analysis performed for the 1982 rulemaking, the model predicted that the marginal cost of removing lead from gasoline would be one cent per gram. EPA has examined the lead usage allocation reports submitted to it by refiners since the 1982 regulations went into effect. Many of them included price information, and the average price at which lead rights sold was well below one cent. Since sales and purchases of lead rights represent a small percentage of total lead use by any given refiner, the cost of these should represent the marginal cost of using one gram less of lead. If these sales occurred at less than one cent per gram, this suggests that the model does not understate costs and may overstate them.

The annual costs of the proposed 0.10 gplg standard for the refinery industry as a whole are shown in Table 5. A more detailed discussion is found in the preliminary RIA and in the EPA cost/benefit analysis.

TABLE 5.—COST OF REDUCING LEAD TO 0.10 GPLG

Year	Total cost (millions of dollars)
1986	575
1987	532
1988	503
1989	480
1990	463
1991	440
1992	432

In addition to analyzing the cost of the proposed standard to the industry as a whole, EPA has examined the impact of a tighter lead standard on certain segments of the refining industry. EPA has focused on small refineries as one segment that might have higher costs than the national average. Small refineries were further divided into three sub-categories: (1) Refineries with both cracking and reforming capacity; (2) refineries with only reforming capacity; and (3) topping plants. Cracking is a process that converts petroleum products that are too heavy to use in gasoline into lighter gasoline grade components that are high in octane. Reforming increases the octane of gasoline components. Refineries with cracking and reforming capability can make high octane gasoline and can convert (through cracking) a larger fraction of their heavier petroleum fractions to gasoline. Topping plants do not have enough equipment to make any of their product into gasoline directly. They purchase additives and blending components to bring their gasoline components up to required specifications.

EPA has modeled each sector of the small refinery industry, and cost estimates for each sector are contained in the initial regulatory flexibility analysis, which has been included in the docket. Assuming that current gasoline production volumes are maintained, small cracking refineries will have increased costs of $19.1 million per year, and small reforming refineries will have increased costs of $15.1 million per year. The cost increases for topping plants could not be directly calculated, since these depend on the price of blending components that they must purchase. However, EPA estimated the increase in the value of blending components to the refiners that sell them. Assuming that they pass such increased costs on to the topping plants when they sell them, their costs are estimated to increase by $2 million.

2. Benefits of 0.10 gplg Standard

EPA also has estimated the value of the benefits that it believes would result from the proposed standard of 0.10 gplg. These benefits fall into three categories: (1) Vehicle maintenance savings; (2) benefits from reduced misfueling; and (3) health benefits from lead emission reductions.

a. *Vehicle Maintenance Benefits.* First, lead has long been known to result in increased maintenance costs for vehicles. EPA has estimated the maintenance savings that would accrue to owners of cars and light-duty trucks that use gasoline with a reduced lead content of 0.10 gplg.

Use of leaded gasoline increases the rates at which mufflers and tailpipes rust out, spark plugs foul, engine deposits build up, and oil is contaminated necessitating more frequent oil changes. In addition, lead-induced fouling of spark plugs leads to poorer fuel economy between spark plug changes, even if they are changed more frequently with leaded fuel. Use of leaded gasoline tends to plug catalytic converters, increasing back pressure and decreasing engine performance, and also degrades the performance of oxygen sensors in newer vehicles. This results in incorrect fuel metering, which may reduce performance and fuel economy. Lead is also corrosive in heavy-duty gasoline engines used in medium and heavy-weight trucks, and will adversely affect their spark plugs, mufflers and engine oil.

EPA has quantified several of these maintenance and fuel efficiency benefits, including exhaust system (muffler and tail pipe), spark plug, and engine oil maintenance benefits for cars and light-duty trucks. Fuel efficiency benefits calculated include those from improved oxygen sensor performance and from the higher BTU content of unleaded gasoline. These are shown in Table 6. The derivation of these maintenance and fuel efficiency savings is discussed in the preliminary RIA and the EPA cost/benefit analysis. In addition, EPA is working on the quantification of benefits for heavy-duty and off-the-road vehicles. These will be placed in the rulemaking docket if timely completed.

TABLE 6-A.—MAINTENANCE BENEFITS OF REDUCING LEAD TO 0.10 GPLG [1]

[Millions of 1983 dollars]

Year	Spark plugs	Oil changes	Exhaust systems	Total [2]
1986	74	314	452	840
1987	68	296	420	784
1988	62	282	393	737
1989	52	273	376	701
1990	55	262	356	672
1991	52	255	344	651
1992	53	262	351	665

[1] Estimates assume that there is no misfueling.
[2] Columns may not add due to rounding.

TABLE 6-B.—FUEL EFFICIENCY BENEFITS OF REDUCING LEAD TO 0.10 GPLG [1]

[Millions of 1983 dollars]

Year	Oxygen sensor	Btu content	Total
1986	22	338	360
1987	26	303	329
1988	29	269	298
1989	31	201	232
1990	33	133	166
1991	35	133	168
1992	37	133	170

[1] Estimates assume that there is no misfueling.

b. *Benefits from Reducing Misfueling.* Because leaded gasoline with 0.10 gram of lead per gallon, assuming it remains at the current 89 octane level, is more expensive to make than unleaded regular gasoline at its standard 87 octane level, EPA believes that the current price differential between unleaded and leaded gasoline will be reversed, with unleaded gasoline becoming the less expensive product. EPA believes that this price differential change will eliminate virtually all fuel switching.

Fuel switching destroys the effectiveness of catalytic converters, thereby increasing emissions of hydrocarbons, carbon monoxide, and nitrogen oxides. EPA has estimated the benefits of avoiding this damage in two ways. The simplest and most straightforward approach is to estimate the value of the pollution control equipment destroyed by misfueling. Because all cars are not misfueled in their first year, EPA estimated the depreciated value of catalysts in older vehicles in order to compute the benefits of not destroying such pollution controls. EPA did this by estimating the total lifetime amount of pollutants removed by a catalyst in the average car, and repeating that calculation for the pollutants removed in the remaining lifetime of the vehicle. If, for example, a two-year-old catalyst had already achieved 20% of its expected lifetime emissions reduction and thus only had 80% left, it was valued at 80% of its original price. This methodology is described more fully in the EPA cost/benefit analysis noted above. EPA's estimate of the value of avoiding misfueling by this method is shown in Table 7.

Table 7 also shows the Agency's estimate of this value derived by directly estimating the benefits to the health and welfare of the U.S. population from better control of HC, NO_x and CO emissions. The control of the first two types of emissions would likely result in fewer cases of asthma attacks, minor illnesses leading to restrictions in activity, crop loss, and property damage, because reducing HC and NO_x emissions leads to reductions in ozone levels. However, we were unable to obtain reliable estimates of changes in long-term chronic health conditions due to reducting ozone levels, or to value the reductions in CO emissions. The data and calculations used to estimate these benefits are discussed in more detail in the preliminary RIA and the EPA cost/benefit analysis.

TABLE 7.—BENEFITS OF REDUCED EMISSIONS OF HC, CO, AND NO_x DUE TO REDUCING LEAD TO 0.10 GPLG

[Millions of 1983 dollars]

Year	Implicit value of catalysts	Direct estimates	Average of 2 estimates
1986	332	363	348
1987	335	366	351
1988	334	354	344
1989	339	358	348
1990	345	365	355
1991	355	376	365
1992	364	385	375

c. *Health Benefits from Lead Emission Reductions.* EPA also estimated the benefits of reducing the number of incidences of children whose blood lead levels exceed the level currently considered to require medical assistance. For children who meet the CDC definition of lead toxicity (see Part III.C.2, above), the Agency estimated the savings in medical costs that would occur due to the reduced number of incidences at those levels. As noted below, monetary benefits were not estimated for reductions in the number of incidences at lower blood lead levels. The CDC recommendations for medical testing and treatment were used to estimate the average medical cost of $950 that would be saved for each child whose blood lead level would be brought below 30 μg/dl.

EPA also calculated benefits due to avoiding reduced performance in school among children in the higher categories of lead toxicity. These children were considered equivalent to the children in the exposed group in the studies of De la Burde and Choate (1972, 1975). De la Burde and Choate found a statistically significant 4–5 point IQ difference between 70 high-lead children and a control group of children drawn from the same clinic population and matched by relevant socioeconomic characteristics. These studies were favorably reviewed in EPA's 1978 NAAQS criteria document for lead. The 1975 follow-up study also found that reduced performance persisted three years later, even after treatment and reduced blood lead levels, and that the children in the exposed group were seven times more likely to be left back a grade or referred to a school psychologist as were children in the control group. Based on this reduced performance, EPA estimated the benefits of avoiding such a loss as equal to the cost of tutoring or special education programs that might help to restore these children's performance. These benefits, and the avoided medical costs, are shown in Table 8. A more detailed discussion of the calculation of these benefits is contained in the preliminary RIA and the EPA cost/benefit analysis.

TABLE 8.—HEALTH BENEFITS OF REDUCING LEAD TO 0.10 GPLG

[Millions of 1983 dollars]

Year	Medical	Reduced performance	Total
1986	$49	$222	$271
1987	45	201	246
1988	41	184	225
1989	37	167	204
1990	35	154	189
1991	31	137	168
1992	30	132	162

d. *Other Benefits.* Reducing lead in gasoline would also result in public health benefits for which EPA has not been able to assign monetary values, but which may be significant. These benefits are reductions in the number of incidences of children whose blood lead levels exceed levels at which adverse health effects occur. These benefits are discussed in the following portion of this notice, Part V.C.

3. Costs and Benefits of Total Ban

EPA has also calculated the costs and benefits of a 1995 total ban on lead in gasoline. These numbers are subject to considerable uncertainty because they require projecting petroleum demand and leaded/unleaded splits far into the future. If leaded gasoline demand is higher than projected, the cost will be higher, as will the benefits (including the lead health benefits). EPA has estimated that the costs of going to a no-lead standard in 1995 would be $468 million, compared to the current standard. This would result in 29,000 fewer incidences of lead toxicity (using the current CDC definition) and monetized benefits of $1,374 million. These are divided into maintenance benefits of $681 million, conventional pollution benefits of $405 million, fuel efficiency benefits of $138 million, and lead health benefits of $150 million. Net monetized benefits are therefore estimated to be $906 million in 1995.

C. Health Impacts

The primary impact of this proposal would be to reduce human exposure to environmental lead, in particular to reduce such exposure by the group most at risk, pre-school children. Based on the discussion in Part III.C of this notice concerning the health effects of gasoline lead, the impacts of the lead emissions discussed in Part V.A can be quantified in terms of reductions in the number of incidences of children whose blood lead levels exceed various levels.

EPA's methodology in determining these numbers of incidences is discussed in Chapter V of the EPA cost/benefit analysis. Using this methodology, EPA has estimated the number of incidences of children whose blood lead levels would exceed various levels under the proposed 0.10 gplg standard.

Blood lead levels above 30 μg/dl are of particular concern because this is the level of undue exposure to lead established by the Centers for Disease Control. A 0.10 gplg standard effective in 1986 would result in 52,000 fewer incidences of children exceeding a blood lead level of 30 μg/dl in that year. In 1988, the number is predicted to be 43,000 incidences. The lower number of incidences in 1988 is due to the fact that such numbers decline over time due to the increased use of unleaded gasoline. The impact on other blood lead levels may also be estimated. For example, the proposal would result in 1,726,000 fewer incidences of children exceeding a blood lead level of 15 μg/dl in 1986, and 1,476,000 fewer incidences in 1988. Over the period 1986 to 1992, the proposed 0.10 gplg standard is estimated to result in an aggregate 280,000 fewer incidences of children exceeding a blood lead level of 30 μg/dl and 9.6 million fewer incidences exceeding a level of 15 μg/dl. Table 9 summarizes these impacts.

In addition to the beneficial health impacts from reducing lead emissions, excess emissions of HC, CO and NO_x that result from misfueling will be reduced to the extent that misfueling is reduced as a result of this proposal. The EPA cost/benefit analysis contains a detailed discussion of the health impacts that may be achieved through such a reduction in emissions of these pollutants.

TABLE 9.—NUMBER OF INCIDENCES OF CHILDREN WHOSE BLOOD LEAD GOES FROM ABOVE TO BELOW THE INDICATED BLOOD LEAD LEVEL

[Thousands of incidences][1]

Blood lead level	Year 1986	1987	1988	1989	1990	1991	1992
30 (μg/dl)	52	47	43	39	36	32	31
25	172	157	144	130	119	108	103
20	563	518	476	434	400	357	348
15	1,726	1,597	1,476	1,353	1,252	1,125	1,098

[1] Assumes no misfueling.

Emissions of ethylene dibromide (EDB), a potential human carcinogen, would also be reduced as a result of this proposal. EDB is used as a lead scavenger in leaded gasoline to prevent undue build-up of lead deposits in engines and exhaust systems. Based on emission factors derived by Sigsby et al. (1982), national motor vehicle tailpipe emissions of EDB in 1986 under the 0.10 gplg proposal would be reduced by 94%, or 143 metric tons. In addition, EPA has calculated that motor vehicle evaporative emissions of EDB would be reduced by 34 metric tons and that EDB emissions from the distribution of leaded gasoline would decrease by 7 metric tons. Total emissions of EDB would therefore be reduced by 184 metric tons not counting tank leakage and spillage. These calculations are explained in the preliminary RIA.

D. Air Quality Impacts

This proposal would result in reduced emissions of several motor vehicle pollutants. The reductions in lead emissions have been previously discussed in Part V.A of this notice. Analysis of ambient lead levels in the past has indicated a close relationship between gasoline lead use reductions and ambient air lead concentrations in areas where lead air quality is not significantly impacted by the stationary sources. For example, a March 1984 EPA report ("National Air Quality and Emissions Trend Report, 1982") indicated a 64% drop in ambient lead concentrations at 46 urban sites over the period 1975–82, a period in which gasoline lead dropped 69%. Thus, it is predicted that ambient lead readings at monitors affected by mobile sources would be reduced substantially. The magnitude of such reductions approaches that of the decrease in lead use on a locality-by-locality basis. Thus, for a standard of 0.10 gplg, the improvement in air quality could be by as much as 91% in the year that the standard is implemented. Under a no lead standard, ambient lead readings at monitors affected solely by mobile sources could drop to as low as zero.

As discussed earlier, when misfueling occurs there will be, in addition to lead emissions, increased emissions of HC, CO, and NO_x. These excess emissions are due to lead affecting the combustion process in the engine and, more importantly, to lead altering the efficiency of the catalytic converter, which can result in its total deactivation. To the extent the proposed 0.1 gplg standard limits or prevents misfueling, there will be a positive benefit in the form of reductions in the amount of emissions of these pollutants.

Under the proposed 0.10 gplg standard, EPA believes that leaded gasoline would cost more to produce than unleaded gasoline. Under the assumption that this would eliminate all misfueling, it is possible to estimate the emission reductions that would result. A vehicle misfueled to the extent of permanent damage to the catalyst will emit excess emissions throughout its life. Preventing a vehicle from ever misfueling would avoid this future stream of excess emissions. The "value" of this stream of avoided emissions in the year the program is implemented can be calculated. The EPA cost/benefit analysis has calculated the magnitude of such avoided emissions for a number of years, assusing that all misfueling is discountinued in the indicated year. These emission reductions are listed in Table 10.

TABLE 10.—REDUCTIONS IN EMISSIONS

[Thousands of metric tons]

Pollutant	1986	1987	1988	1989	1990	1991	1992
CO	1,646	1,650	1,653	1,670	1,697	1,749	1,794
HC	247	247	236	237	241	248	254
NO_x	81	90	97	103	109	112	118

E. Energy Impacts

Because many of the alternatives to lead for boosting octane require additional processing of gasoline components, the proposed 0.10 gplg standard would result in increased use of energy. This reflects the fact that energy is expended in the course of operating this processing equipment. EPA has estimated that this increase in energy use would not exceed the equivalent of 10,000 barrels per day of crude oil in any year, less than 0.1% of current crude oil usage in the United States. Compared to the benefits that would result from this proposal, this increased energy usage is not substantial. The results of the EPA analysis have been placed in the rulemaking docket.

F. Impacts on Use of Other Additives

To prohibit the use of a fuel additive under section 211(c), section 211(c)(2)(C) of the Act requires the administrator to find that such a prohibition will not cause the use of another fuel or fuel additive that will produce emissions that will endanger the public health or welfare to the same or greater degree than the fuel additive to be banned. Accordingly, the Agency considered the possibility that a low-lead standard or a total ban on the use of lead in gasoline might (in the absence of further regulatory action) cause the use of other additives as lubricating agents for valves and/or as octane enhancers. EPA looked at both the direct health effects of the additives and their effect on catalytic converters.

Under a total ban on the use of lead in gasoline, refiners might consider use of other additives for one or both of the following purposes: to serve as an engine valve lubricant; and/or to increase the octane of gasoline. Under the proposed 0.10 gplg standard, however, they would likely be considered for use only as an octane enhancer because such a standard would provide an adequate amount of lead for valve lubrication.

Under a total ban on lead, refiners might consider use of substances such as phosphorous, sodium, or MMT for the purpose of valve lubrication. The additive most likely to be considered for this purpose is phosphorus because it is believed that this substance, used in the same quantity as lead, can serve the same function as a value lubricant. Unfortunately, phosphorus is more harmful to catalysts than lead. Since phosphorus presently costs more than lead and does not appear to increase octane, its use in gasoline would probably not cause the amount of fuel switching to increase. However, since the catalyst is more easily damaged by phosphorus than by lead, the damage caused by any given amount of misfueling with phosphorus would be greater than for the same amount of misfueling with lead. Further, although not much research has been done on the health effects of phosphorus, some organophosphorus pesticides have been shown to be potentially harmful. MMT and sodium have also been mentioned in the literature as possible substitutes for lead. However, there is very little information available about their properties as a valve lubricant.

To increase the octane of gasoline, various methods are technically feasible for use in the production both of unleaded gasoline and of low-lead leaded gasoline under the proposed 0.10 gplg standard. Octane in these products could be enhanced by the use of one or more of the following means: (1) Further refinery processing with catalytic crackers and reformers (and possibly isomerization units); (2) increased use of MMT or other chemical additives; and/or (3) increased use of alcohol. Further refinery processing will not result in damage to catalysts or in adverse health effects, and is not coverd by section 211(c)(2)(C) of the Act in any case since it does not involve the use of an additional fuel or fuel additive. The other two means of octane enchancement are of more concern to the Agency.

MMT is a manganese additive whose use is currently allowed only in leaded gasoline. MMT may not be added to unleaded gasoline unless a waiver has been granted under section 211(f)(4) of the Act. Under section 211(f)(2) of the Act, concentrations of manganese in gasoline under any such waiver may not exceed 0.0625 gram (1/16 gram) per gallon of unleaded gasoline. Two waivers for the use of MMT in unleaded gasoline have been requested by Ethyl Corporation, but both were denied by EPA due to the lack of complete date concerning the emissions effects of this additive. 43 FR 41424 (Sept. 18, 1978) and 46 FR 58363 (Dec. 1, 1981).

The other known octane enhancer is alcohol. Ethanol or methanol may presently be used in leaded gasoline. Their use in unleaded gasoline is allowed only if a waiver under section 211(f)(4) of the Act has been issued (to date, 5 such waivers have been granted and 4 have been denied). The use of high levels of alcohols (in excess of that allowed by existing waivers) may have some adverse emission impacts. Their effect on catalysts is not great, although there may be some adverse effects on the carbon canisters used to control evaporative HC emissions. Unwaived alcohols may also have adverse effects on the polymers and elastomers in vehicles. Since vehicles that use leaded gasoline are generally older, some of these parts are already worn, so the alcohol may increase their wearout. Further, the use of such alcohol in the tank of an older vehicle may cause clogged fuel filters, since it picks up old dirt particles. If the fuel metering system is affected adversely, the vehicle may run poorly. For these driveability reasons, it is unlikely that major refiners would use high levels of alcohols in low-lead gasoline produced for older vehicles.

The Agency has broad authority under section 211(f) of the Clear Air Act to prohibit or control the use of new additives in unleaded gasoline. Generally, a waiver must be obtained under section 211(f)(4) of the Act for the use of any fuel additive in unleaded gasoline unless it is "substantially similar" to an additive use in the certification of 1975 or later model year vehicles under section 206 of the Act, 42 U.S.C. 7525. Under section 211(f)(4), a waiver may be granted only if the Administrator finds that an additive and its emission products—

> will not cause or contribute to a failure of any emission control device or system (over the useful life of any vehicle in which such device or system is used) to achieve compliance by the vehicle with the emission standards with respect to which it has been certified pursuant to section 206.

Thus, the Agency has broad authority to control the use of octane enhancers such as alcohol and MMT in unleaded gasoline. As noted above, the Agency has in the past denied waivers to several products containing these additives when their manufacturers were unable to demonstrate that the statutory criteria for approval would be met. The Agency will continue to utilize its authority under section 211(f) to assure that vehicle emission standards are met and that emission control equipment is protected. While this mechanism would not be available to control the use of additives in leaded gasoline produced under a 0.10 gplg standard, the Agency has broad authority under section 211(c) to control such additives should they pose a greater danger to the public health or welfare, or to emission control devices, than is now anticipated. This authority is, of course, also available in regard to unleaded gasoline.

Based on presently-available information, therefore, the Agency believes that a prohibition on the use of lead in gasoline would not cause the use of another fuel or fuel additive that will produce emissions that will endanger the public health or welfare to the same or greater degree than the use of lead. In any case, should use of any alternative additive or fuel pose a danger to the public health or welfare, the Agency has ample authority under section 211 (c) and (f) to prohibit or control its use, as outlined above.

The Agency is aware, however, that there is not a great deal of information currently available on some of the issues related to alternatives to lead usage in gasoline. Therefore, the Agency specifically requests comments on: (1) What additives might be used in place of lead as a valve lubricant and/or octane enhancer in unleaded gasoline (upon a total ban on lead in gasoline) or in leaded gasoline produced under a 0.10 gplg standard; (2) the extent to which such additives are likely to be used; (3) the health effects of such additives; and (4) the effects of such additives on emission control devices, particularly catalytic converters.

VI. Other Alternatives Considered

A. Incentives for State/Local Anti-Fuel Switching Enforcement Programs

On January 1, 1984, EPA announced the availability of a technical report on anti-tampering and anti-fuel switching programs designed to reduce in-use motor vehicle emissions. 49 FR 1984. This report includes the most recent data on fuel switching rates, information on the effects of misfueling on vehicle emissions, and detailed estimates of HC and CO emission reduction benefits achievable through various types of control programs. Programs to control misfueling generally include a check for tampering with the fuel filler inlet and the catalytic converter, and may also include use of a lead-sensitive paper to detect lead deposits in vehicle tailpipes. These programs may be included by states as control strategies in their state implementation plans (SIP's) for CO and/or ozone, and the emission reduction benefits provided in the report may be used as part of a demonstration of attainment or maintenance of these ambient air quality standards.

While EPA strongly encourages states to include these types of programs in their SIP's, the provision of SIP credits for these activities will have only a partial effect on the elimination of fuel switching. First, only certain areas are likely to establish anti-fuel switching programs. The most likely are those areas unable to demonstrate attainment of the CO and/or ozone ambient standards by the end of 1987 through the use of reasonably available control technology (RACT). However, SIP revisions demonstrating attainment of these standards were required to be submitted to EPA by July 1, 1982, and nearly all states have submitted at least draft revisions. Thus, some states which may have considered inclusion of these programs in their SIP's if SIP credits had been available earlier may now be committed to other control measures. Other areas may, however, consider these programs in order to provide a margin for economic growth and/or as a strategy to maintain the ambient air quality standards.

Because the provision of SIP credits is only likely to encourage anti-misfueling programs in certain areas, this policy will not be enough by itself to solve the nationwide fuel switching problem described in Part III.B of this notice, above. Any anti-misfueling program of the types discussed in the SIP credit document that would be aimed at the nationwide fuel switching problem would likely be very expensive and burdensome for state/local governments, since they would necessitate programs to inspect all vehicles in the U.S. and to assure that misfueled vehicles are repaired. Nor would such programs do anything to solve the lead-related health problems caused by the legal use of leaded gasoline. Therefore, the Agency does not consider the SIP credit policy to be an adequate substitute for the regulatory program proposed in this notice, nor does it consider the requirement of a national anti-misfueling inspection program to be a feasible alternative.

B. Federal Ban on Fuel Switching by Individuals

Another alternative considered by the Agency is a Federal ban on fuel switching by individual vehicle owners and operators. Under § 80.22(a) of the current regulations (Title 40, Code of Federal Regulations), only retailers and wholesale purchaser-consumers (and their employees and agents) are liable for the introduction of leaded gasoline into a vehicle designed for unleaded gasoline. Such persons are also liable for causing or allowing the introduction of leaded gasoline into such vehicles, but others (e.g., non-fleet vehicle operators) are not themselves liable for such introductions.

The Agency believes that a direct prohibition on individual fuel switching, coupled with a vigorous enforcement effort, would be effective in reducing the amount of fuel switching. However, the Clean Air Act presently does not clearly authorize such a prohibition, and the Agency recently asked Congress to amend the Act to specifically prohibit both fuel switching and tampering with emission control equipment by individuals. Even if such authority is available, however, it is unlikely to eliminate this practice entirely, because fuel switching by retailers and others currently liable under the regulations occurs today at a significant rate and because enforcement of regulations affecting millions of gasoline refuelings would be difficult. Furthermore, such a ban would not affect the legal use of leaded gasoline or the adverse health impacts caused by lead emissions from such use. Therefore, this alternative would not achieve all of the purposes of the proposed rule.

VII. Additional Information

A. Executive Order 12291

Executive Order (E.O.) 12291 requires the preparation of a regulatory impact analysis for major rules, defined by the Order as those likely to result in:

(1) An annual adverse effect on the economy of $100 million or more;

(2) A major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or

(3) Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

EPA has determined that this proposed regulation meets the definition of a major rule under E.O. 12291, and has prepared a preliminary regulatory impact analysis (RIA). That document, along with this notice of proposed rulemaking, has been submitted to the Office of Managment and Budget (OMB) for review under Executive Order 12291. Any comments from OMB and any EPA responses to such comments are available for public inspection at the Central Docket Section, U.S. Environmental Protection Agency, West Tower Lobby, 401 M Street, SW., Washington, D.C. 20460 (Docket EN-84-05). A copy of the preliminary RIA has also been placed in the rulemaking docket.

B. Regulatory Flexibility Act

The Regulatory Flexibility Act, 5 U.S.C. 601–612, requires that Federal agencies examine the impacts of their regulations on small entities. Under 5 U.S.C. 604(a), whenever an agency is required to publish a general notice of proposed rulemaking, it must prepare and make available for public comment an initial regulatory flexibility analysis (RFA). Such an analysis is not required if the head of an agency certifies that a rule will not have a significant economic impact on a substantial number of small entities, pursuant to 5 U.S.C. 605(b). EPA has prepared an initial regulatory flexibility analysis for the regulations proposed in this notice, and this initial RFA has been placed in the rulemaking docket.

The initial LRFA examines the impact of the proposed regulations on small refineries, as currently defined in 40 CFR 80.2(p). As part of its analysis, the Agency considered three alternatives to the proposed regulations in order to determine whether they would meet the same environmental goals in a manner that would reduce adverse impacts on such refineries. The alternatives analyzed are: (1) Make no changes to the current regulations; (2) establish a higher gasoline lead content standard for small refineries than for the other refineries; (3) allow small refineries more time than others to meet a uniform gasoline lead content standard. EPA concluded that these alternatives would not meet the same environmental goals as the proposed regulations, and for this and other reasons outlined in the initial RFA rejected these alternatives.

C. National Academy of Sciences Recommendations.

Section 307(d)(3) of the Clean Air Act, 42 U.S.C. 7607(d)(3), requires that rulemaking proceedings under section 211 of the Act, 42 U.S.C. 7545, take into account any pertinent findings, comments, and recommendations by the National Academy of Sciences. Pertinent findings by the National Academy of Sciences are contained in the 1980 report, "Lead in the Human Environment," prepared by the Committee on Lead in the Human Environment of the National Academy of Sciences. The major recommendations in this report pertinent to regulatory controls are the following:

(1) "Efforts to control exposure to lead should proceed, with full acknowledgement of the necessary imprecision of estimates of the costs, risks, and benefits."

(2) "Control strategies should be based on coordinated, integrated measures to reduce exposures from all significant sources."

(3) "Improved institutional mechanisms should be developed to permit a more systematic, consistent approach to the management of lead hazards."

(4) "Expanded and more concerted efforts should be made to identify children at risk and remove sources of lead from their environments. A serious effort should also be made to reduce the 'background' level of exposure of the general population to lead. The most important elements in control strategies include population screening, lead paint removal, reduction of lead emissions from gasoline combustion, and reduction of lead levels in foods."

The Agency has taken these recommendations into account in the development of this regulatory proposal and believes the proposal is fully consistent with them. The proposed gasoline lead content standard of 0.10 gplg would reduce by at least 91% lead emissions from gasoline consumption, which adversely affect children and other "at risk" groups in the population.

D. Paperwork Reduction Act

The information collection requirements contained in the rule which this notice proposes to amend have been cleared previously by OMB under control number 2000-0041. See 48 FR 13430 (March 31, 1983). The changes to the information requirements proposed in this notice have been submitted to OMB for review under the Paperwork Reduction Act of 1980, 44 U.S.C. 3501 *et seq.* The major change in information collection requirements that would result from the proposed regulatory revisions involves the inter-refinery averaging provisions. Since this notice proposes to eliminate these provisions starting on January 1, 1986, the amount of time now needed to comply with related reporting requirements would be eliminated. EPA estimates that this change would result in an approximately one-third reduction in the total reporting burden associated with the gasoline lead content regulations. Comments on proposed changes to the information collection requirements should be submitted to the Office of Information and Regulatory Affairs of OMB, marked "Attention: Desk Officer for EPA."

List of Subjects in 40 CFR Part 80

Fuel additives, Gasoline, Motor vehicle pollution, Penalties, Reporting and recordkeeping requirements.

(Secs. 211 and 301(a) of the Clean Air Act, as amended (42 U.S.C. 7545 and 7601(a)))

Dated: July 30, 1984.

William D. Ruckelshaus,

Administrator.

PART 80—REGULATION OF FUELS AND FUEL ADDITIVES

For the reasons set out in the preamble, Part 80 of Title 40 of the Code of Federal Regulations is proposed to be amended as follows:

1. Section 80.2 is proposed to be amended by revising paragraph (g) and by rescinding, removing and reserving paragraphs (p) and (q), to read as follows:

§ 80.2 Definitions.

* * * * *

(g) "Unleaded gasoline" means gasoline which is produced without the use of any lead additive and which contains not more than 0.01 gram of lead per gallon and not more than 0.005 gram of phosphorus per gallon.

* * * * *

(p)–(q) [Reserved]

* * * * *

2. Section 80.4 is propoed to be revised to read as follows:

§ 80.4 Right of entry; tests and inspections.

The Administrator or his authorized representative, upon presentation of appropriate credentials, shall have a right to enter upon or through any refinery, retail outlet, wholesale purchaser-consumer facility, the premises or property of any distributor or importer, or any place where gasoline is stored, and shall have the right to make inspections, take samples and conduct tests to determine compliance with the requirements of this part.

3. Section 80.20 is proposed to be revised to read as follows:

Note.—Text enclosed in arrows indicate language which would be included if the Agency promulgates a total ban on the use of lead in gasoline effective on January 1, 1995.

§ 80.20 Controls applicable to gasoline refiners and importers.

(a) *Refiners.* (1) In the production of gasoline at a refinery, a refiner shall not:

(i) Produce leaded gasoline whose average lead content during any calendar quarter ending prior to January 1, 1986, exceeds 1.10 grams of lead per gallon of leaded gasoline.

(ii) Procedure leaded gasoline whose average lead content during any calendar quarter beginning on or after January 1, 1986, ▶and ending prior to January 1, 1995,◀ exceeds 0.10 gram of lead per gallon of leaded gasoline.

▶(iii) Produce leaded gasoline on or after January 1, 1995.◀

(2) Except as provided in paragraph (d)(1) of this section, compliance with the requirements of paragraph (a)(1) (i) and (ii) of this section shall be determined by dividing the total grams of lead used in the production of leaded gasoline (including the lead in gasoline blending stocks and components used in such production) at a refinery during a calendar quarter by the total gallons of leaded gasoline produced at the refinery in the same calendar quarter.

(3) For each calendar quarter ▶ending prior to January 1, 1995,◀ each refiner shall submit to the Administrator a report which contains the following information for each refinery:

(i) The total grams of lead in the refinery's inventory (including its lead additive inventory and its inventory of gasoline blending stocks and components) on the first day of the calendar quarter;

(ii) The total grams of lead (including lead additives and lead in gasoline blending stocks and components) received by the refinery during the calendar quarter;

(iii) The total grams of lead additives shipped from the refinery during the calendar quarter;

(iv) The total grams of lead in the refinery's inventory (including its lead additive inventory and its inventory of gasoline blending stocks and components) on the last day of the calendar quarter;

(v) The total gallons of leaded gasoline produced by the refinery during the calendar quater;

(vi) The total gallons of unleaded gasoline produced by the refinery during the calendar quarter;

(vii) The total grams of lead used in the production of leaded gasoline (including lead additives and the lead in gasoline blending stocks and components used in such production) by the refinery during the calendar quarter;

(viii) The average lead content of each gallon of leaded gasoline produced by the refinery during the calendar quarter;

(ix) The total grams of lead used in the production of products other than gasoline by the refinery during the calendar quarter, by type of product;

(x) The total gallons of products other than gasoline in which lead was used that were produced by the refinery during the calendar quarter, by type of product; and

(xi) If any of the products listed in paragraph (a)(3)(x) were sold or otherwise transferred to another refinery during the calendar quarter, the total gallons of each product so transferred, the total grams of lead in each product so transferred, the name and address of the refinery to which the transfer was made, and the date of such transfer.

Reports shall be submitted within 15 days after the close of the calendar quarter on forms prescribed by the Administrator.

(b) [Reserved]

(c) *Importers.* (1)(i) No importer shall sell or offer for sale leaded gasoline which has been imported into the United States and whose average lead content during any calendar quarter ending prior to January 1, 1986, exceeds 1.10 grams of lead per gallon of such gasoline.

(ii) No importer shall sell or offer for sale leaded gasoline whose average lead content during any calendar quarter beginning on or after January 1, 1986, ►and ending prior to January 1, 1995,◄ exceeds 0.10 grams of lead per gallon of such gasoline.

►(iii) No importer shall sell or offer for sale leaded gasoline on or after January 1, 1995.◄

(2) Except as provided in paragraph (d)(1) (i) and (ii) shall be determined by calculating:

(i) The lead content of each shipment of imported leaded gasoline sold by the importer during a calendar quarter, determined by the performance by the importer of the test for lead in gasoline set forth in Appendix B of this part upon a representative sample of gasoline in the shipment;

(ii) The total gallons of leaded gasoline in each such shipment;

(iii) The total grams of lead in each such shipment, determined by multiplying the lead content of the shipment by the total gallons of leaded gasoline in the shipment;

(iv) The total grams of lead in such shipments sold during the calendar quarter;

(v) The total gallons of leaded gasoline in all such shipments sold during the calendar quarter;

(vi) The average lead content of all imported leaded gasoline sold during the calendar quarter, determined by dividing the total in paragraph (c)(2)(iv) by the total in paragraph (c)(2)(v).

(3) For each calendar quarter ►ending prior to January 1, 1995, ◄each importer who sells imported leaded gasoline or imported gasoline blending stocks or components shall submit to the Administrator a report which contains the following information:

(i) The information described in paragraphs (c)(2) (i) through (vi) of this section;

(ii) The lead content of each shipment of imported gasoline blending stocks or components sold by the importer during the calendar quarter determined by performance by the importer of the test for lead in gasoline set forth in Appendix B of this Part upon a representative sample of gasoline blending stocks or components on the shipment;

(iii) The total gallons of gasoline blending stocks or components in each such shipment;

(iv) The total grams of lead in each such shipment, determined by multiplying the lead content of the shipment by the total gallons of gasoline blending stocks or components in the shipment;

(v) For each shipment of imported leaded gasoline or imported gasoline blending stocks or components sold during the calendar quarter: name and address of importer; date and place of entry; and vessel or carrier number (where applicable); and

(vi) For each shipment of imported leaded gasoline blending stocks or components sold during the compliance period, the name and address of the refinery or the other person to which the sale was made, the total gallons of product sold, the total grams of lead in the product sold and the date of such sale.

Reports shall be submitted within 15 days after the close of the calendar quarter on forms prescribed by the Administrator.

(4) Any importer who adds lead to gasoline or gasoline blending stocks or components during a compliance period shall also submit a report pursuant to paragraph (a)(3) of this section.

(d) *Inter-refinery averaging.* (1) As an alternative means of demonstrating compliance with the requirements of paragraph (a)(1)(i) or paragraph (c)(1)(i) of this section, one or more refiners may demonstrate such compliance by constructively allocating lead usage between or among two or more refineries in any manner agreed upon by the refiner(s), so long as:

(i) The average constructive lead content of leaded gasoline produced in a calendar quarter by each refinery does not exceed 1.10 grams of lead per gallon of leaded gasoline produced;

(ii) The total amount of lead usage in a calendar quarter by all such refineries, as constructively allocated and reported, is equal to the total amount of lead actually used in the calendar quarter by all such refineries;

(iii) The actual or constructive lead content of gasoline produced by each refinery does not exceed any applicable state statutory or regulatory standards; and

(iv) The constructive allocation agreement is made no later than the final day of the calendar quarter in which the lead allocated is actually used.

(2) Any refiner who demonstrates compliance with the requirements of this section pursuant to paragraph (d)(1) of this section shall submit to the Administrator, as an additional part of the report required by paragraph (a)(3) or paragraph (c)(3) of this section, the following information:

(i) The total grams of lead actually used by the reporting refinery during the calendar quarter and constructively allocated to another refinery, and the name and address of such other refinery (for each such constructive allocation);

(ii) The total grams of lead actually used by another refinery during the calendar quarter and constructively allocated to the reporting refinery, and the name and address of such other refinery (for each such constructive allocation);

(iii) The total grams of lead constructively used in the production of leaded gasoline by the reporting refinery during the calendar quarter, as determined by performing the following calculations upon the total grams of lead actually used by the reporting refinery during the calendar quarter: (A) Subtracting the total grams of lead indicated in paragraph (d)(2)(i) of this section, and (B) adding the total grams of lead indicated in paragraph (d)(2)(ii) of this section; and

(iv) For each refinery, the constructive average lead content of leaded gasoline produced by the reporting refinery during the calendar quarter, as determined by dividing the total grams of lead indicated in paragraph (d)(2)(iii) of this section by the total gallons of leaded gasoline produced by the reporting refinery during the calendar quarter; and

(v) When compliance is demonstrated pursuant to paragraph (d)(1) by more than one refiner, each such report shall also include supporting documentation adequate to show the agreement of all such refiners to the constructive allocation of lead usage stated in the report.

(3) For purposes of paragraphs (d)(1) and (d)(2) of this section, the total amount of imported leaded gasoline sold during a compliance period of each importer shall be treated as the output of a single refinery, and each importer shall be treated as a refiner.

(4) The provisions of paragraph (d)(1), (d)(2), and (d)(3) of this section shall not be applicable during any calendar quarter beginning on or after January 1, 1986.

[FR Doc. 84-20429 Filed 7-31-84; 8:50 am]

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Lead-Laden Freeway Parks Hazardous to Kids

by Louis Freedberg

From his small street front office in the Pilsen neighborhood of Chicago, Guillermo Gomez looks across the street to busy Interstate 94 leading to downtown Chicago. Under the freeway is a fallen monument to a city planner's dream! Sawed-off metal stumps of playground equipment, unused benches, pieces of concrete and tarmac scattered randomly about, and a rusted basketball hoop are all that is left of the neighborhood's freeway park.

It seemed like a great idea when the park was first installed. The space under the freeway was unused and it was cheap — in a neighborhood that desperately needed more recreation facilities for its children. The Pilsen neighborhood is a mixed residential-industrial area only ten minutes from downtown Chicago, with a primarily Latino population. Gomez is the organizer for the local community organization, the Pilsen Housing and Business Alliance. His main priority is to bring more jobs into the community, and to revitalize some of the abandoned factories that dominate the local landscape.

"One day a tire flew off the freeway into the living room of the people across the street," Gomez recalls. "The kids also didn't like it too much because of the fumes." So his organization voted to ask the city to remove the freeway park. Before he could contact city officials, maintenance crews came down on their own — apparently under instructions from the state bureaucracy concerned about falling concrete from the freeway. In a matter of hours, the park was dismantled. Now all that is left is a cold, sunless space, dominated by the echoing noise of cars and trucks passing overhead.

What Gomez and others in the neighborhood did not know is that parks and playgrounds under or near freeways contain a less visible but more pervasive hazard than flying truck tires: lead in the soil and in the air.

Few Communities Realize Danger

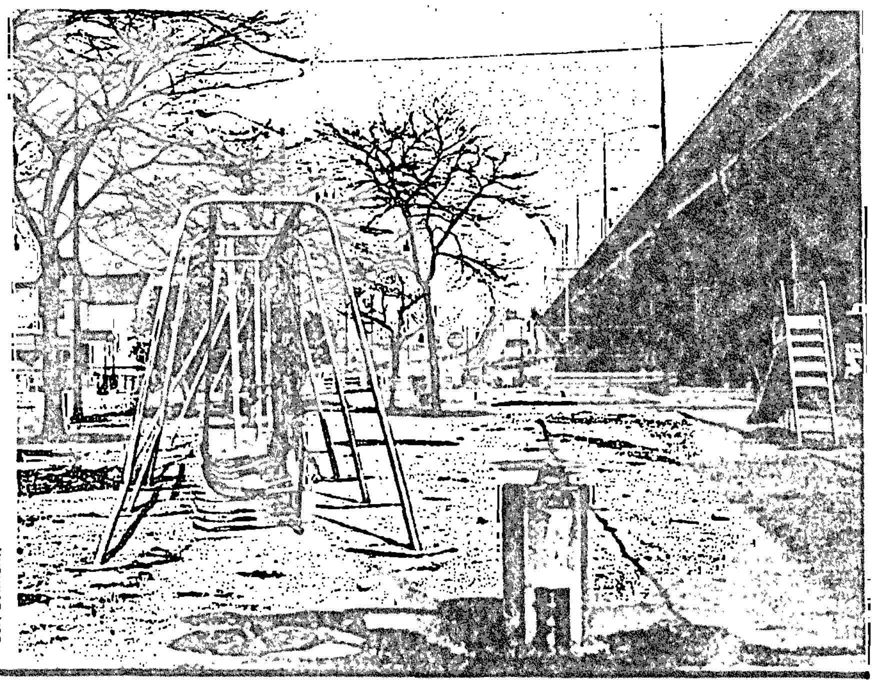
They also did not know about a study conducted just a few miles away, in the nearby town of Morton Grove. Much of the traffic in and out of Chicago passes through this bedroom community, better known as the catalyst for hand gun control across the country than for its efforts to control exhaust fumes from freeway traffic which sometimes reach 100,000 cars per day. Five years ago, the Morton Grove Board of Trustees commissioned the Illinois Institute for Environmental Quality to look at the possible impact of lead deposits in air and soil near freeways on children — the only community before or since to commission such a study.

Researchers found extremely high lead levels in the air and soil near freeways running through the town. They also found elevated blood levels in children living near the freeway. The study concluded that "airborne lead from automobiles using heavily traveled roadways may contribute to the blood lead levels of children, especially to that of pre-school children." Among the report's recommendations: putting up baffles, such as trees, to deflect some of the lead, and, more ominously, educating parents "so that they understand the importance of keeping non-food items out of their children's mouths and for frequent and thorough handwashing."

In Oakland, California, the interchange in the Grove-Shafter freeway is an impressive piece of engineering, with its matrix of clover leaf on- and off-ramps. The freeway was designed to revitalize a decaying downtown, and has partially succeeded in doing that. Like many cities across the country, the city decided to build a series of parks and playgrounds under or near the freeway. In one of the parks, children from a neighboring elementary school came over to pay regularly during recess.

By chance, the county had received federal funding to begin a Lead Prevention Project. Part of its job was to identify sources of lead poisoning in children. Testing was done in the Grove-Shafter parks. What health officials found surprised them. In the soil and on the picnic tables were levels of lead as high as 9,500 parts per million (ppm) — over nine times the "safe" level of 1000 ppm.

As a result of its findings, the picnic tables in the parks were removed. Children from the elementary school were advised not to play there during their breaks. "They put in a little walkway and a few receptacles," says Gordon Coleman, the health officer in charge of



Albert Belmonte

the testing. "It's the kind of place where you can sit and read." Health officials put out the clear message that the freeway parks were no place for small children, or for eating.

In spite of the Oakland and Morton Grove findings, public officials in urban areas across the country express little or no concern about the possible presence of lead in freeway parks. There has been virtually no systematic testing of soils in outdoor areas where children play.

New York Report Never Released

An exception is in New York City, where six years ago Dr. Anita Curren, then with the city health department, did a study of lead levels in city parks. What she came up with closely matched the Oakland results.

"We found when playgrounds were near a major thoroughfare there were higher lead levels," Curren says. Several parks had lead levels higher than 1000 ppm. What concerned Curren especially was the possibility of small children with sticky or wet hands picking up soil, and then putting their hands in their mouths. In a "worst case" scenario, Curren and her researchers dipped a lollipop in sandlots, and concluded that a child licking the lollipop would ingest 90 milligrams of lead, an amount much higher than the established "safe levels."

Remarkably, Curren's report was never released. The results were never written up. She moved to another job in Westchester County.

New York City now has no official policy regarding construction of playgrounds near or under freeways. Although the park official in charge of construction admitted that freeway parks are "generally a vile place to be," he expressed no concern about the possibility of lead deposits.

In Los Angeles, where park officials have been forced into a somewhat higher level of environmental sensitivity, they acknowledge that there might be a problem in "one or two" parks in East Los Angeles where high lead levels were found. Yet no precautions have been taken to keep children out of these parks, nor to warn parents of possible dangers.

The furthest Los Angeles has come — which is further than most other cities — is to adopt a policy barring construction of more facilities in freeway parks, and also not to encourage "active" sports and activities there.

A reason for this modest first step may lie in a study conducted several years ago in Los Angeles which showed that young people playing basketball in those dime-a-dozen courts under freeways have below-normal oxygen levels in their blood due to auto emissions.

Experts Disagree on Freeway Lead

The dangers of lead near freeways has been so well documented in the scientific literature that the lack of awareness or concern among city planners and park officials is astounding. One of the reasons for the lack of concern may have to do with the general agreement among experts that the major cause of lead poisoning in children are lead-based paints. Since these were banned ten years ago, the incidence of actual lead poisoning among children has declined steadily. The use of unleaded gasoline has also lowered lead levels in children.

The dangers of lead near freeways has been so well documented in the scientific literature that the lack of awareness or concern among city planners or park officials is astounding.

Yet even with less use of lead-based paints and less lead in gasoline, large numbers of children in the U.S. still have blood lead levels higher than the existing — and probably inadequate — standard of 30 micrograms per decilitre established by the Center for Disease Control. The latest statistics, released in May, 1982 by the Department of Health and Human Services, show that one out of twenty, or a staggering 675,000 children between the ages of 6 months and 5 years have blood lead levels above the standard. The data for black children is even more chilling: 12 percent, or one in five, black children have elevated blood lead levels.

To establish the extent of lead hazards in playgrounds near freeways, three questions have to be answered. Is the amount of lead emitted by cars sufficient to pose a hazard to children? Is the amount of lead deposited in the soil near freeways sufficient to pose a hazard to children? Is the amount of lead deposited in the soil near freeways sufficient to enter the bloodstream of children? And once the lead has entered the blood stream, does it enter it in sufficient quantity to harm children?

The scientific literature provides a convincing affirmative answer to each of these questions.

Research Suggests Danger to Kids

Hundreds of thousands of tons of lead are emitted into the atmosphere each year from various sources. Over 90 percent comes from cars. In California alone, 93 percent of the 13,500 tons of lead in the atmosphere comes from automobile emissions. In Los Angeles, 18 tons of lead a day are spewed from the exhausts of cars. Over half of the lead — 57 percent — is deposited on freeways or on the streets next to them.

After taking hundreds of soil samples throughout the state, the California Lead Prevention Project concluded that "there is no doubt that urban California soil is sufficiently contaminated with lead to pose a potential hazard to many children." One example: of 114 soil samples taken in elementary schools, 26 were found to have lead levels of over 1000 ppm. Researchers speculate the elevated lead levels may have come from lead being deposited on school roofs from passing cars, and then washed down by rain into the school yards.

The Morton Grove and other studies clearly demonstrate that children who breathe air with elevated lead levels will have higher lead levels in their blood. The Dept. of Health and Human Services study of lead levels of children in the U.S. also shows that because of higher metabolic rates and greater physical activity, children will inhale two to three times as much airborne lead as adults do.

A related problem is that, according to a 1974 Dartmouth Medical School study, the closer one gets to the ground the greater the concentration of lead in the air. The study found twice as much lead in the air within four feet of the ground than above it.

What this suggests is that children playing near freeways, where there is a demonstrated higher level of lead in the air, will absorb more lead because of their size and stage of development.

Lead in Soil May Be Bigger Problem

But the major hazard to children in freeway parks comes not from air, but from the soil. Lead in soil near freeways has been found in a sufficient number of sites around the country that it must be assumed that it poses a danger to children who play near freeways.

Once in the soil, the chances are high that the lead will find its way into the bloodstream. A 1977 EPA review of the literature concluded that "the data from all these studies can be summarized fairly succinctly. There is evidence that children can pick up lead from their environment by getting it on their hands."

But how much of a danger? In the vernacular of health professionals, a lead-poisoned child is one who has blood lead levels grater than 80 micrograms per deciliter. A lead-burdened child is one with a lead level of over 30 micrograms. However, as more research gets done on lead, the standard for what is regarded as harmful to a child has been steadily lowered. The Center for Disease Control, the official arbiter of these matters, first defined hazardous levels of blood

Physicians Raise New Concern Over Lead Levels in Soil

Although countless studies have measured the lead in the air (gasoline emissions dumped 90,000 tons of lead into the environment in 1980) very few public officials seem concerned with lead in the soil.

But local physicians say that some children consume soil containing lead, and for that reason the government should increase soil testing in order to decrease the risk of children contracting lead poisoning.

Sound ridiculous that a child would eat dirt? It doesn't to Dr. Daniel Hryhorczuk, assistant professor of Environmental and Occupational Health at the University of Illinois's School of Public Health.

He says that lead in the soil "poses a problem to children with 'pica', which is a medical term for the habit of putting dirt in their mouths."

Hryhorczuk does not believe a single dose of dirt will give a child a serious case of lead poisoning. But it can add to whatever lead may be in his or her system.

"There's a build-up of lead in many city children," he said. "Lead is excreted from the system very slowly, and it can build up to a toxic level."

The effects of lead poisoning vary, depending on the degree of exposure. Dr. Quentin Young, former chairman of the Department of Occupational Medicine at Cook County Hospital, said "the effects of blood poisoning from lead range from nothing, to brain damage. It depends on the amount of lead in the blood."

"You won't go to a picnic at a freeway park and get lead poisoning," he added, "but the risk of lead poisoning is significant if you are continually exposed to the air in these parks, if you or your children use the park regularly."

Children are especially sensitive to the effects of lead. *Chemical and Engineering News* reported that "studies have estimated that lead poisoning *from all sources* cost the U.S. $1 billion per year, with up to 80 percent of that cost for special education for learning impaired children." (Aug. 9, 1982)

Much of that lead came from automobile exhaust and lead-based house paint. But it is conceivable — in the eyes of Hryhorczuk and Young — that lead in the soil contributed to the problem.

The same *Chemical and Engineering News* article reported that the E.P.A. recently considered reducing the lead standards for fuel. Part of the reason the EPA decided to keep the present standard was that "the cost for treating the additional 200,000 to 500,000 children that would develop lead poisoning would range from $140 million to $1.4 billion per year."

What, then, should be done about lead in parks? Nobody suggested closing any of the 10-12 parks near freeways in Chicago, which include the lake front park and parks located beneath freeway overpasses. (This number does not include suburban parks located near freeways and other heavily trafficked roads.)

As far as Hryhorczuk is concerned, the best — albeit most difficult to achieve — solution is to "don't use lead in gasoline."

Both Young and Hryhorczuk believe more soil testing is needed before anything is done to parks.

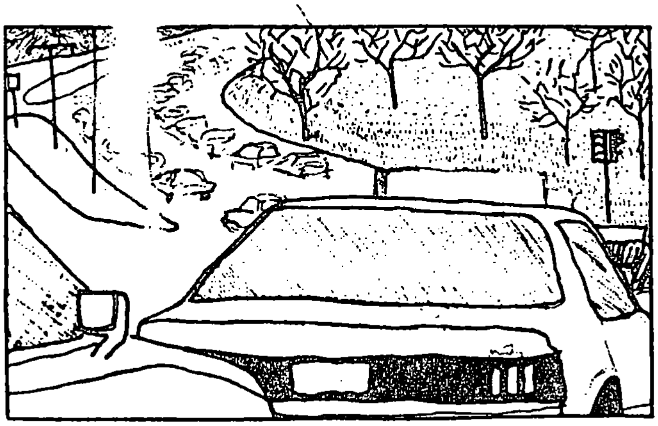
So far very little soil testing has been done by the Park District, partly because the District doesn't feel this is a priority.

George Wo.f, a Park District supervisor, claimed that "very little" soil te ing is done, and that the city doesn't have a policy regard g the testing of soil before putting in a park.

The Cook (ounty Inspectional Services Department of Environmental ontrol deals with air pollution. The department's techn .l services manager, Charles Legges, said he "doesn't thir here would be much of a problem with lead in the soil beca e lead levels in the air are so low."

But it is lik the measurements Legges is referring to were taken at lor listances from freeways. Kevin Green, a researcher for 3E, says that "a lot of people think the lead monitors are o far from expressways."

If Green is ght, perhaps Legges ought to put measurements for lead in s n his department's agenda. —*D.McG.*



lead as 50 micrograms, that level was then lowered to 40. The "safe" level now stands at 30.

The major impetus for lowering the standard came from what is now generally regarded as the classic study in the field, even though it was completed only five years ago. Joseph Needleman and his colleagues at Harvard Medical School, rather than looking at actual physical symptoms of lead poisoning, looked at performance on intelligence tests, behavior in the classroom, and reports from teachers and parents. They found that children with blood levels of 30 micrograms and lower did worse on intelligence tests and also displayed a wide range of behavior problems sufficient to "interfere with classroom performance." Needleman concluded that the CDC standard of 30 micrograms was too high. Yet the CDC continues to hold to the 30 microgram standard.

Other studies since Needleman's have confirmed his findings. In California, Wesolowski and his colleagues found that blood levels in children were higher near freeways, and that these children "usually did not display classical toxicity symptoms." Instead, he found that children exposed to low lead levels over a long period of time leads to a variety of clinical symptoms, including "mental deterioration, enzyme activity changes, impairment of fine motor development, concept formation and behavior."

Studies clearly demonstrate that children who breathe air with elevated lead levels will have higher lead levels in their blood.

How Much Lead Is Too Much?

All this suggests that it is not sufficent to be only looking for "acute" symptoms of lead poisoning, but that there should be greater concern for all sources of lead absorption in the bloodstream. If the trend of research of recent years continues, it is likely that in the not too distant future it will be shown that *no* blood lead levels are safe.

The controversy surrounding the "safe" blood lead standard also raises questions about the "safe" level of lead in soil. The medical community and local governments generally consider soil with 1000 parts per million or more of lead as hazardous. Yet an EPA review of the literature concluded that levels of lead in soil far lower than the accepted standard contribute to lead in the bloodstream. EPA reviewers suggest that soil lead levels over 500 ppm should be cause for concern.

While much of lead in the air from exhaust fumes is blown away into the atmosphere, and lead in paint can be gradually eliminated as old housing stock get replaced, lead from cars accumulates for decades on soil adjacent to freeways. Nor does it get washed away after a good rainfall. The California Lead Prevention Project concluded that "once soil is contaminated from lead it may take hundreds to thousands of years for the lead to be removed by nature." For example, in the unlikely eventuality that cars were banned from the Los Angeles freeways beginning tomorrow, it would take one hundred years to erode one centimeter of soil, if the soil was flat, bare, and absorbed water quickly. For clay soil with vegetation, it would take much longer — 37,000 years in fact.

Exposure to low lead levels over a long period of time leads to a variety of clinical symptoms, including mental deterioration, enzyme activity changes and impairment of fine motor development, concept formation and behavior.

New Public Policy Needed

The actual levels will vary according to where the freeway is situated, wind directions, type of soil, amount of vegetation, type of surface covering, amount of traffic, and so on. But because the evidence of possible hazards is so incontrovertible, a new public policy regarding the use of public space near or under freeways is needed.

This public policy would involve the following:

- Testing of soils, sand lots, and picnic tables in parks within 100 yards of a freeway.
- Posting of signs warning parents to make sure their children don't put their hands in their mouths, and to wash their hands when they get home.
- Installing drainage systems to divert later run-off from freeways away from existing parks and playgrounds.
- In parks with high lead levels, picnic tables and sand lots should be removed, along with other contaminated soils.

The available evidence suggests that playgrounds under or near freeways are tempting but possibly hazardous solutions to the dual problems of unused space and providing needed recreation facilities. Publicly owned space near freeways should in the future only be used for parking lots, storage or warehouse space, or other uses which will keep human exposure to a minimum.

Local governments cannot control the number of cars on a freeway, nor can they control the inevitable play habits of young children. What they can control is the open space under their jurisdiction. Those spaces should not provide yet another link in the chain that has caused unacceptably high levels of lead in too many of America's children.

The landscape architect in the Chicago Parks Department, while denying that lead in freeway parks is a problem, admitted that evergreen trees do not grow very well, if at all, near freeways. "The fumes and soot from car exhausts close the pores of the leaves," he said.

Environments where trees cannot survive are not the places where children should be expected to play, grow, and hopefully flourish.

AMERICAN JOURNAL OF Public Health reprint

Lead Concentrations in Inner-City Soils As a Factor in the Child Lead Problem

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Abstract. Soil samples were randomly collected from 422 vegetable gardens in a study area centered in downtown Baltimore, Maryland, and having a radius of 48.28 km (30 miles). The levels of lead, four other metals (cadmium, copper, nickel, and zinc), and pH were measured for each location. The application of multi-response permutation procedures, which are compatible with mapping techniques, reveals that lead (as well as cadmium, copper, nickel, and zinc) is concentrated and ubiquitous within the soils of the inner-city area of Metropolitan Baltimore. The probability values that the concentration of metals occurred by chance alone vary from about 10^{-15} to 10^{-23} depending on the metal considered. Our findings pose environmental and public health issues, especially to children living within the inner-city. (*Am J Public Health* 1983; 73:1366–1369.)

Health researchers in the United States have disclosed that undue exposure to lead is a nationwide public health problem which in the general population is prevalent among children and associated with degree of urbanization.[1] A federally funded child screening program, begun in mid-1971, revealed that excessive lead exposure was occurring among 15–20 per cent of the children in many inner-city locations,[2] although the average for all inner-city children is presently about 12 per cent.[1] Reduction of lead-based paint has been the prime focus for prevention of lead poisoning up to this time. However, about 40 to 45 per cent of the confirmed lead toxicity cases in the US could not be directly related to lead paint.[3] Research into non-traditional sources of lead is clearly needed and has been requested.[4] Leaded gasoline is also a significant source of lead.[5] Airborne lead has been recognized as a significant source of indoor lead exposure,[6] but exposure to urban outdoor lead sources has not received the same level of attention by researchers. Several studies describe lead levels in urban soils. For example, toward the city centers of London, Christchurch, and Boston lead levels have been found to increase substantially.[7-9] However, surveys to date have not used appropriate statistical techniques to describe the degree of concentration of lead within an urban area. Our study was designed to measure and survey the distribution of soil lead within metropolitan Baltimore. Since vegetable garden cultivation creates many opportunities for contact between humans and soils, either directly via hand-to-mouth activities or indirectly via food chain linkages or contamination of the living space, we focused our attention on vegetable garden soils.

Methods

Data Collection

We assumed that garden soils would be mixed to spade depth (about 20 to 30 cm). Soil samples were randomly collected from 422 locations within an area defined by a 48.28 km (30 mile) radius from a designated center point (intersection of Baltimore and Charles Streets) of downtown Baltimore. Samples were air dried and sieved with stainless steel (USGS #10) 2 mm mesh screen. Samples were prepared by shaking a 1:5 ratio of air dried soil to 1M nitric acid extraction solution for two hours. The extracts were filtered and the final extractions were analyzed for lead, cadmium, zinc, copper, and nickel using a Varian atomic absorption spectrophotometer with deuterium background correction. Duplicates were prepared and run for all samples. Soil pH of each sample was measured using a 1:1 ratio of soil and deionized distilled water. One set of measurements (the average of the duplicate samples and pH) was obtained for each of the 422 sites.

Statistical Analysis

The statistical analysis of these data are based on a recently perfected permutation technique termed multi-response permutation procedures (MRPP).[10,11] Unlike most statistical techniques, our MRPP analysis is compatible with the Euclidean geometry on which cartography is based.[12] The 422 soil samples from 422 distinct sample sites comprise the finite population investigated in this study. The response measurements for each soil sample are the x,y coordinates measured cartographically from the designated center of Baltimore. In order to investigate the geographic clustering of high soil lead levels, the 422 soil samples were partitioned at the median value into two groups of 211 each. The MRPP test statistic is based on the average distance between all pairs of sites within the group having higher lead values. The group having lower lead values is treated as the remaining part of the finite population of 422 sites. Under the null hypothesis that the 211 sites of the group having higher lead values have the same chance of arising from any of the 422 sites, the distribution of the standardized MRPP test statistic[10,11] is approximated by the standard normal distribution.[13]

Results

The results of the analysis are summarized in Table 1. In addition to lead, analyses are also reported for cadmium, copper, nickel, zinc, and soil pH. The probability value reported in Table 1 is the proportionate measure of having a

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TABLE 1—Probability of Being Clustered by Chance Alone and Selected Percentile Values for Each Metal (ppm) and Soil pH

Element	Lead	Cadmium	Copper	Nickel	Zinc	Soil Acidity (pH)
N*	422	417	422	419	420	421
Probability‡	10^{-23}	10^{-16}	10^{-15}	10^{-16}	10^{-19}	0.39
	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm
Percentile						
Maximum	10,900.0	13.65	98.70	53.40	4,880.00	8.16
90	777.5	3.17	63.45	8.40	521.00	7.17
80	421.0	1.83	41.10	5.50	325.50	6.88
70	258.5	1.33	29.30	4.45	212.50	6.67
60	167.0	0.82	22.65	3.50	152.00	6.50
50 Median	100.0	0.56	17.25	2.80	92.00	6.32
40	55.5	0.41	13.45	2.40	55.55	6.14
30	35.0	0.29	10.15	1.75	33.45	5.83
20	24.5	0.19	7.40	1.40	18.80	5.51
10	14.5	0.12	5.35	0.85	10.65	5.06
Minimum	1.0	0.02	0.70	0.50	0.30	4.11

*Number of sites (N) varies because of missing values.
‡P-value based on the average distance between all pairs of sites with values greater than or equal to the median value.

more extreme result by chance alone. In the case of lead the odds are less than one in 10^{23} that the clustering of the high lead soils could take place by chance alone.*

The distribution of garden sites in metropolitan Baltimore is illustrated in Figures 1 and 2 for lead and soil pH. The excessive concentration of lead in urban garden soils is indicated by a comparison of locations having values greater than or equal to the median value with locations having values less than the median value in Figure 1. Although somewhat less extreme, analogous concentration patterns of the other metals (cadmium, copper, nickel, zinc) also occurred. In contrast, the location values in Figure 2 indicate no obvious pattern differences for soil pH. To illustrate the soil metal quantities encountered in this study, percentile values are tabulated in Table 1 for each of the five metals and soil pH. We expect that uncultivated soils of metropolitan Baltimore have metal concentrations and distribution patterns similar to the vegetable garden samples analyzed in this study.

Discussion

Although some literature proposes that house paint is the major source of soil lead contamination,[14,15] the urban patterns of soil lead in Baltimore suggests that the inner-city lead contamination is due to another source. Ninety per cent of the inner-city of Baltimore is characterized by unpainted brick buildings. Only in the less dense housing areas away from the city center, where they make up 40 per cent of the structures, do older painted homes become relatively common. However, the site of Baltimore has been the focus of a variety of activities during the course of its evolution from Baltimore Town in 1729 to the present urban industrial center.[16] The metal percentiles reported in Table 1 reflect the history of all activities which contribute metals to the environment such as emissions from industries and incinerators, paints, solders, insecticides, rubbish and relatively recently, emissions from vehicular traffic using leaded gasoline. The last item seems especially relevant because vehicle density and hence vehicular emissions are directly proportional to degree of urbanization.

Because the buildings of inner-city Baltimore are predominantly unpainted brick structures, vehicular traffic as a source of lead needs further comment. According to industry sources, at least 50,000 metric tons of lead were sold in the form of leaded gasoline in the state of Maryland from 1961 through 1981.[17,18] In 1981, Baltimore City accounted for about 8.5 per cent of the State's annual average daily traffic (AADT).** However, during the decades of the 1960s and 1970s, the rapid expansion of suburban communities caused a reduction in the proportion of Baltimore City AADT compared with State AADT. Thus, we estimate that about 5,000 metric tons of lead were emitted into the environment of Baltimore City during the period of 1961 through 1981, and furthermore, that between 5,000 and 10,000 metric tons of lead were emitted into the urban environment of Baltimore City by traffic alone during the past 40 to 50 years.

The lead generated by vehicular traffic is not evenly distributed in the city. It is well known that roadside soil lead levels are directly related to AADT.[19] As traffic increases toward the center of the city, roadside lead concentrations would also increase. Furthermore, a relationship has been demonstrated between lead levels of roadside soils and lead levels of building-side soils. Lead aerosols collect on the sides of buildings and are washed into the soils by precipitation.[20] Recognizing the thousands of tons of lead that have been emitted by traffic, these mechanisms suggest the necessary links between traffic, building sides, and soil lead to account for the elevated lead levels of garden soils near unpainted brick structures in the inner-city of Baltimore.

The excessive concentration of lead in inner-city Baltimore soils probably has a bearing on that city's child lead problems.[21] The acidic pH of the gastric juices provides conditions whereby soil lead becomes readily extracted and available for absorption in the gastro-intestinal tract.[22] It has

*If the MRPP test statistic for soil pH is based on the average distance between all pairs of sites with values less than the median value, (i.e., more acid soils) then the probability value for pH would be 0.56 instead of 0.39 given in Table 1.

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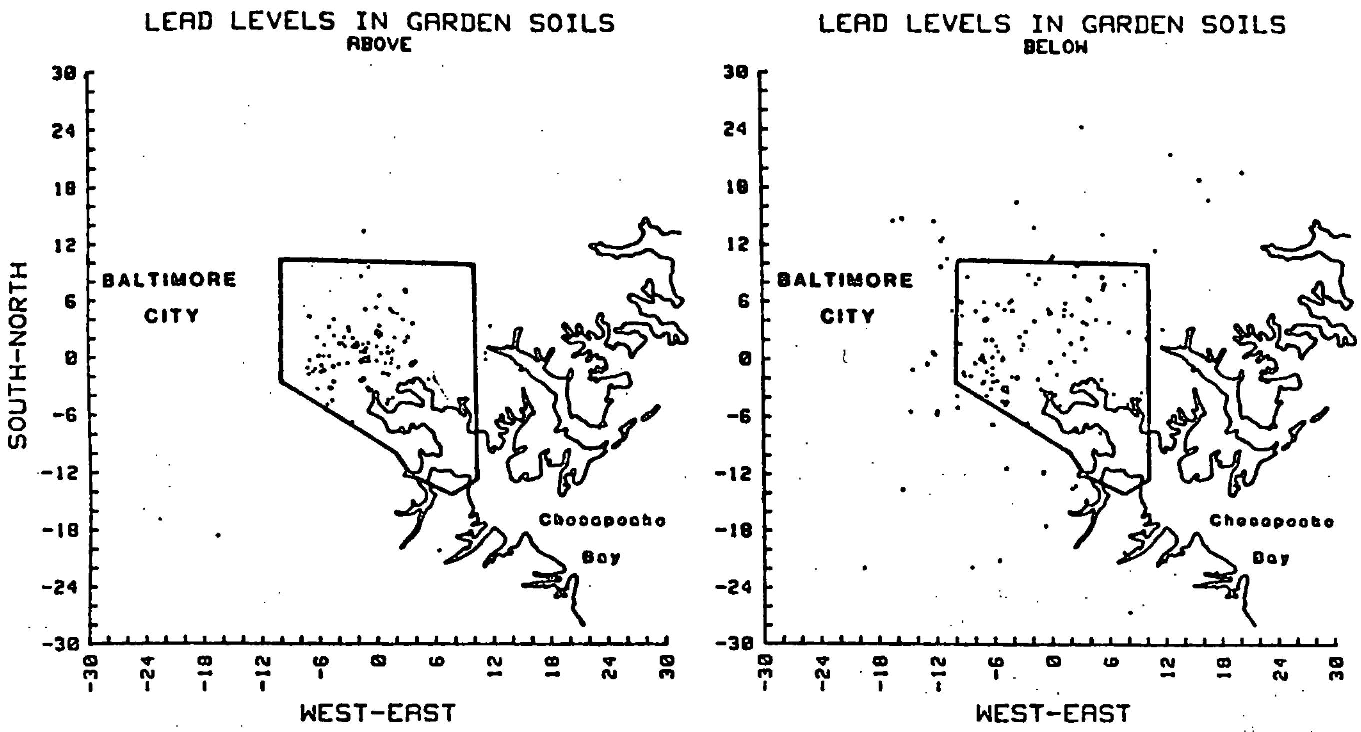

FIGURE 1—Comparison of locations of garden soils exhibiting lead values greater than or equal to the median value (left) with locations of garden soils exhibiting lead values less than median value (right). Note the clustering of garden locations associated with the higher soil lead levels within Baltimore City. Analogous results were also found for cadmium, copper, nickel, and zinc.

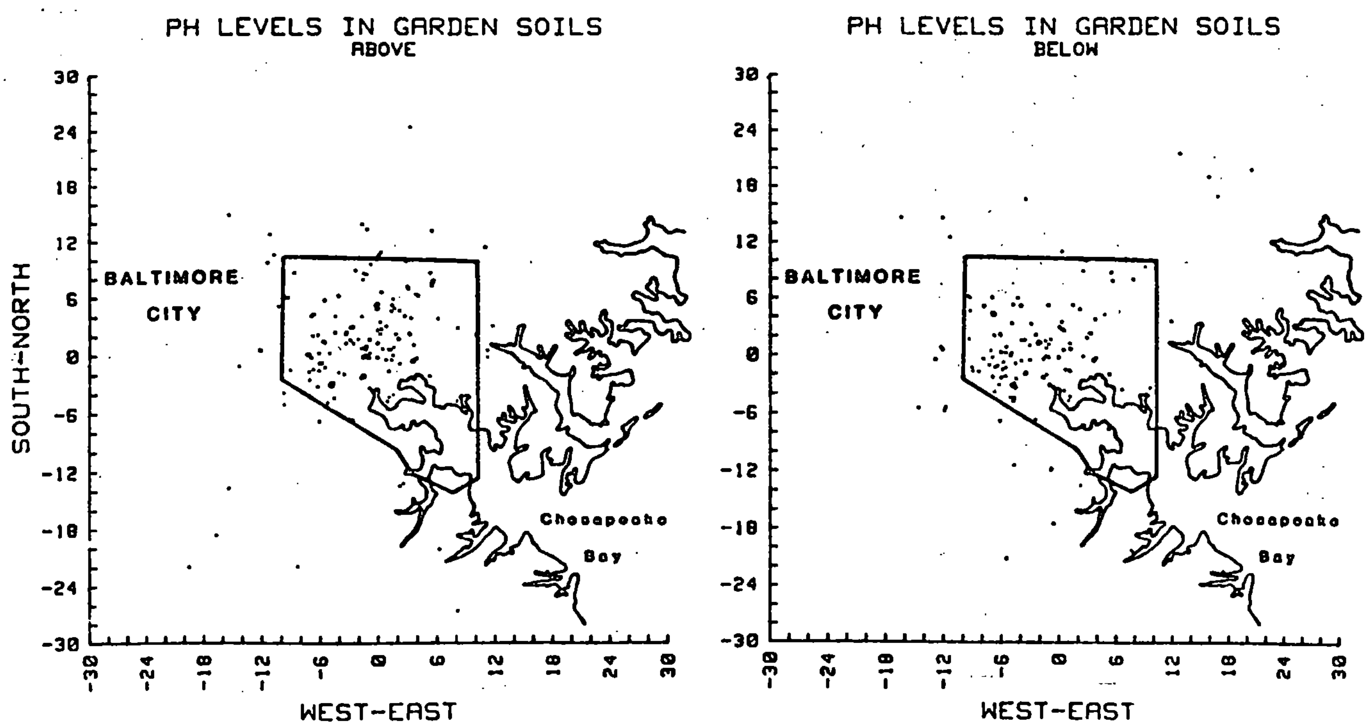

FIGURE 2—Comparison of locations of garden soils having pH values greater than or equal to the median value (left) with locations of garden soils having pH values less than the median value (right). Note the lack of any obvious clustering of locations for either the higher or lower pH values.

been proposed that the maximum daily permissible intake of lead from all sources should be less than 100 micrograms for infants under the age of six months and should not exceed 150 microgram for children between six months and two years of age.[23] Children in the infant-crawling-creeping-toddler stages of development are particularly vulnerable to soil lead because of their small body size, greater lead absorption and retention rate (approximately 50 per cent compared to 8 per cent for adults),[24] and their developmental need to explore and learn through hand-to-mouth behavior.[25-27] The median garden soil (100 ppm) of this study would contribute 100 micrograms of lead per gram of dry soil to the lead intake of a child deliberately or inadvertently ingesting soil during play, mouthing, thumb-sucking, and similar activities. Thus, the high lead soils in this study have the potential of contributing at least 100 per cent and more of the permissible daily lead intake per gram of soil ingested by an infant under six months old, and the majority of the high lead soils would exceed the daily permissible intake by several fold (see Table 1). Lead ingestion is implicated in a variety of learning disabilities and behavioral disturbances among children.[28,29]

While the manner in which the concentration of lead and the other metals occurred, and the environmental and public health problems related to these findings need further investigation, there is no reasonable doubt that lead and the other metals studied are excessively concentrated in the inner-city of Baltimore relative to surrounding areas. Given the extraordinary probability value (10^{-23}) for lead concentration in the center of Baltimore, and the fact that Baltimore is fundamentally similar to other large urban centers, we expect the distribution pattern of soil lead of all large cities to be similar to Baltimore. Thus, the inner-city is a location where, in the course of everyday activities, children face a higher possibility of being exposed to lead than children living in other urban locations. We conclude that soil lead levels are an important measure in accounting for the fact that degree of urbanization correlates with the magnitude of the child lead problem.

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